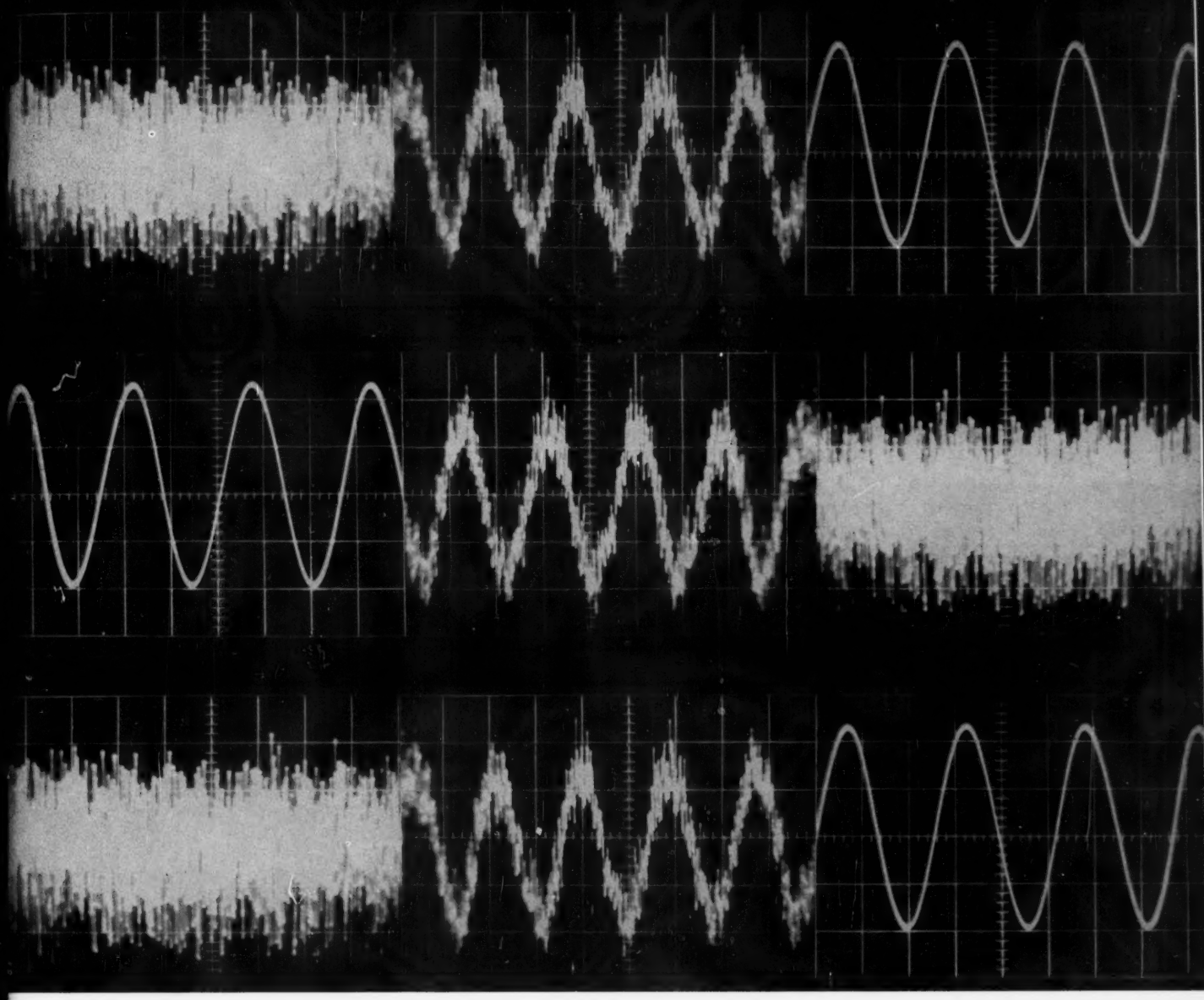
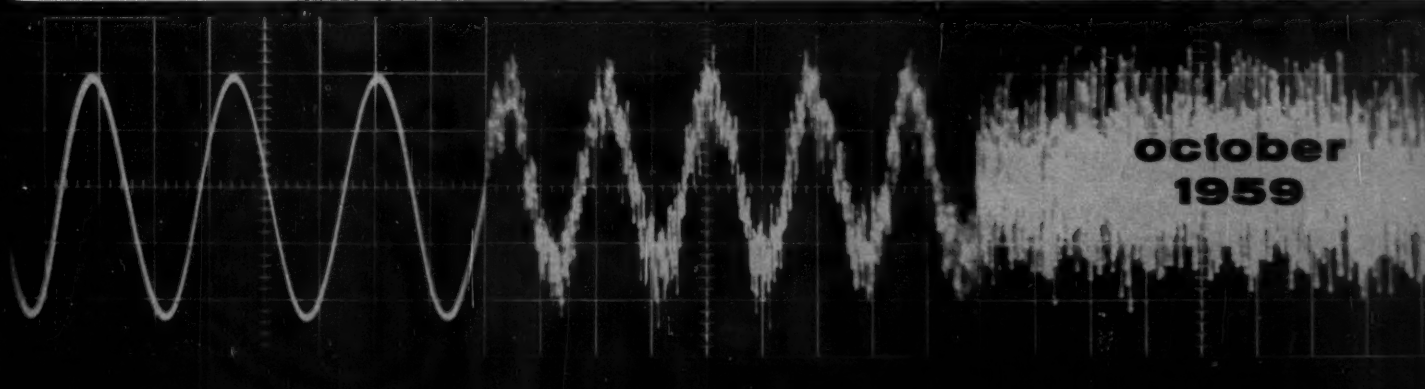


the JOURNAL of environmental sciences

THE OFFICIAL PUBLICATION OF THE INSTITUTE OF ENVIRONMENTAL SCIENCES

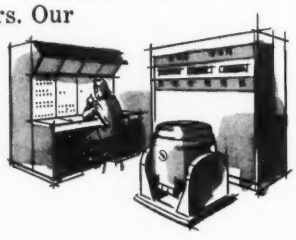


october
1959

NEW in looks, new in efficiency, and forerunner of a great new line of MB vibration exciters... that's the new Model C125.

Once again leading the way, MB has achieved a radical step-up in magnetic circuit efficiency. This new shaker, barely larger than its predecessor, develops 10,000 pounds force output... a 43% gain! Conversely, it calls for less amplifier power than any other electrodynamic shaker of comparable force.

Leading companies in missiles, aircraft and electronics look first to MB for progress in complete vibration test systems. It has been that way for almost 15 years. Our "encyclopedia" of vibration experience is yours to draw on... as is the largest, national, field service staff of specialists. Send for full data.



Pioneer and leader in the field of vibration

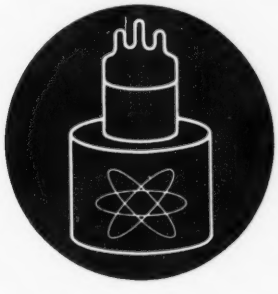
MB MANUFACTURING COMPANY

A DIVISION OF TEXTRON INC., 1078 State Street, New Haven 11, Conn.

New breakthrough in vibration exciter performance!

43% more force output... More efficient utilization of power amplifier!

TIED TOGETHER



MB ELECTRONICS is the new name for MB Manufacturing Company.

This recent change in name is simply a long overdue reflection of the company's proper character. It is a reflection of the company's recognized capabilities in the field of electronic design, in the manufacture of audio range, high fidelity, high power amplifiers, in the programming of advanced vibration testing... and in the capabilities of the largest field service force to properly service electronically driven systems and aid on *any* problem of vibration testing.

As always, you can count on MB to keep you ahead in electronically powered systems of maximum performance capabilities, operating convenience, and test accuracy.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1082 State Street, New Haven 11, Conn.

Sales Representative – Pacific Scientific Co.

the JOURNAL of environmental sciences

VOLUME 2 NUMBER 5

Published for active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Institute of Environmental Sciences.

Charles W. Danielson, Technical Editor OCTOBER 1959

Sound-Induced Vibration	**9**
Improved Optical System	**16**
New Products	**25**
1960 National Meeting	**29**
Environmental Handbook	**30**
The Representative's Environment	**32**
Notes from the Editor	**33**
Technical Information	**35**
Names and Faces	**36**
Membership Information	**44**

INSTITUTE of ENVIRONMENTAL SCIENCES OFFICERS

President	– HAROLD JONES
Exec. Vice President	– WILLIAM VANDAL
Vice President, Fiscal Affairs	– ARTHUR BILLET
Vice President, Membership	– RUSSELL LOWE
Vice President, Local Chapters	– LEON CARVER
Vice President, Publications	– RAYMOND YAEGER
Ex Officio Member	– ROGER AMOROSI

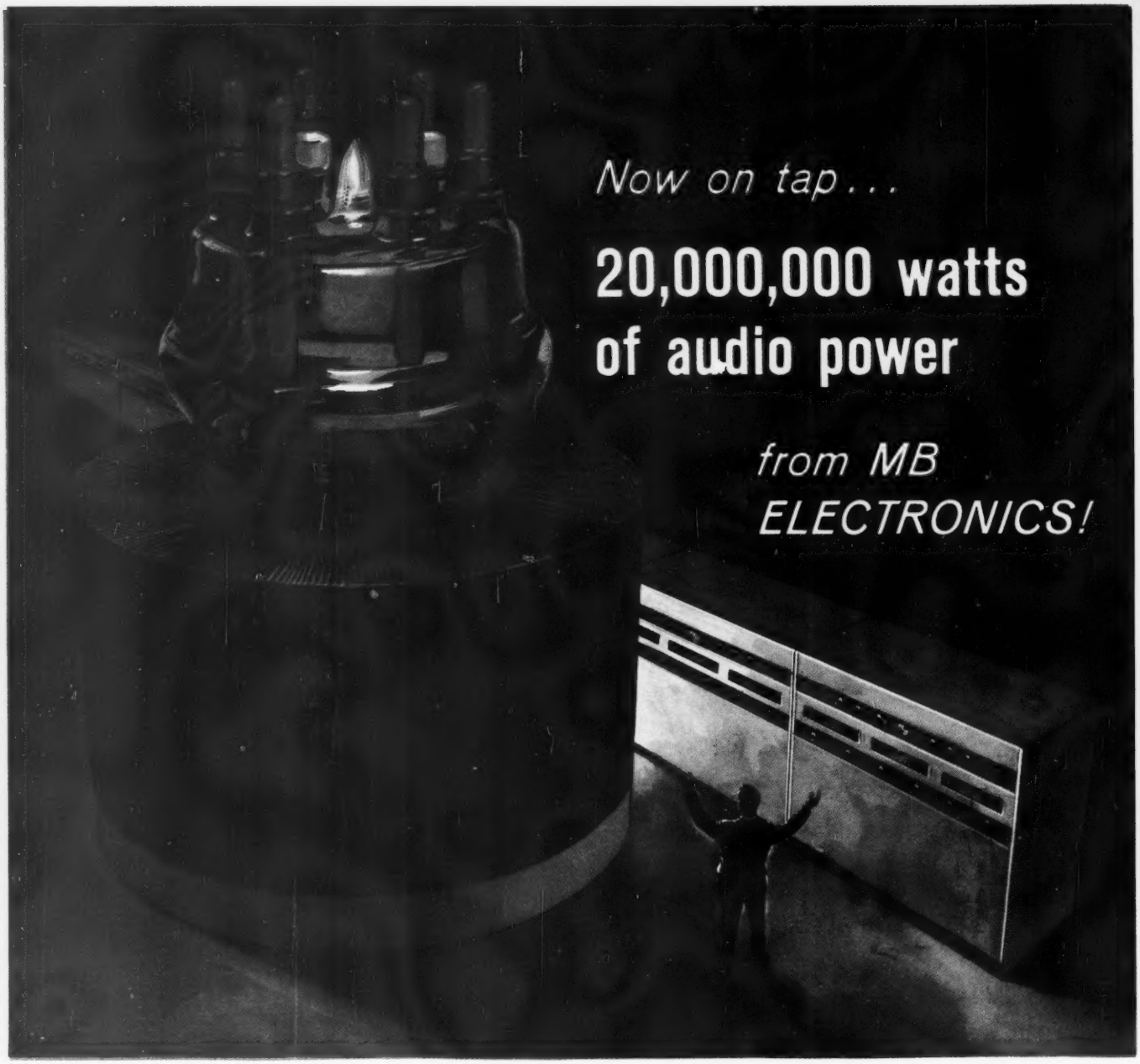
THE JOURNAL OF ENVIRONMENTAL SCIENCES is published bi-monthly at 11916 West Washington Blvd., Los Angeles 66, California. Subscription Rates: $5.00 per year (6 issues) in United States and Possessions and in Canada. $1.00 per copy when available.

Lithographed in USA by Guthrie-Kiefer Co.

Copyright 1959 by Institute of Environmental Sciences.

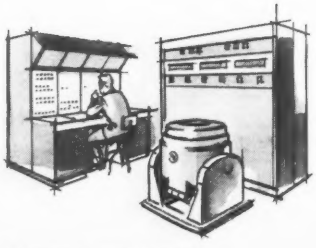
Send all correspondence regarding circulation and advertising material to the office of publication. Send editorial material to I. E. S., H. F. Sander, Box 191, Mt. Prospect, Ill.

We cannot be responsible for unsolicited manuscripts.



TWENTY million watts—that's the cumulative output available from MB power supplies now driving vibration test systems in the field.

The figure is more than a measure of the new importance of vibration testing. It's a measure of MB's technical advancement in the field of electronics for vibration, acoustics, and sonar.



Pioneer and leader in the field of vibration

And it's a measure of the company's unequalled background of experience in designing electronic power for dynamic forces . . . in producing *integrated* vibration testing systems including amplifiers of 100KW output and more, and exciters that utilize amplifier power more efficiently . . . in programming vibration tests to any required specification. This experience is available to you through MB's staff of vibration specialists and the largest force of field service technicians. Avail yourself of their expert recommendations on your vibration test problems.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC., 1082 State Street, New Haven 11, Conn.

Sales Representative – Pacific Scientific Co.

New Chandler Evans

THERMO-RESEARCH CENTER

...designed and built by the men of PTF

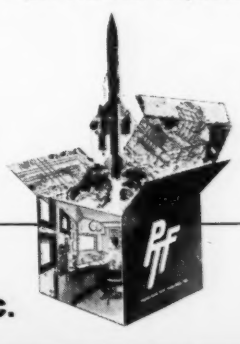
THIS unique center for elevated temperature testing of fuel system components features the most advanced instrumentation, equipment and design. Composed of an open air Test Platform and a remote, sound-proofed, air-conditioned, maximum safety Control House (shown above), the Chandler Evans Thermo-Research Center is a model of integration of electronic, hydraulic, mechanical and construction components into a single operative package.

Designed and constructed by the men of PTF, it is a model, too, of the company's capability to serve as a single source for force simulative test facilities, from conception . . . through design and construction . . . to check out.

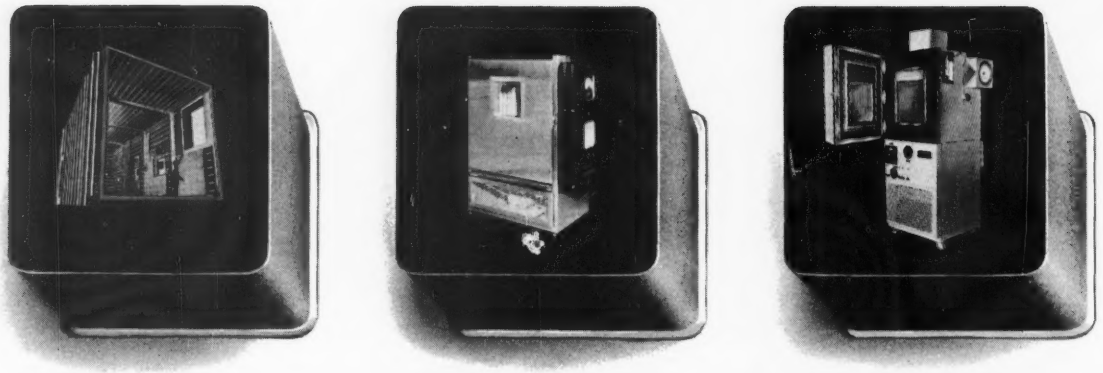
A brochure detailing the design and construction service available to you from PTF will be sent on request. Write PROPULSION TEST FACILITIES, INC., 20 Fitch Street, New Haven 11, Conn. (An affiliate of MB Electronics, a division of Textron Electronics, Inc.) Western Headquarters, Culver City, Calif. World-wide engineering representation.

for

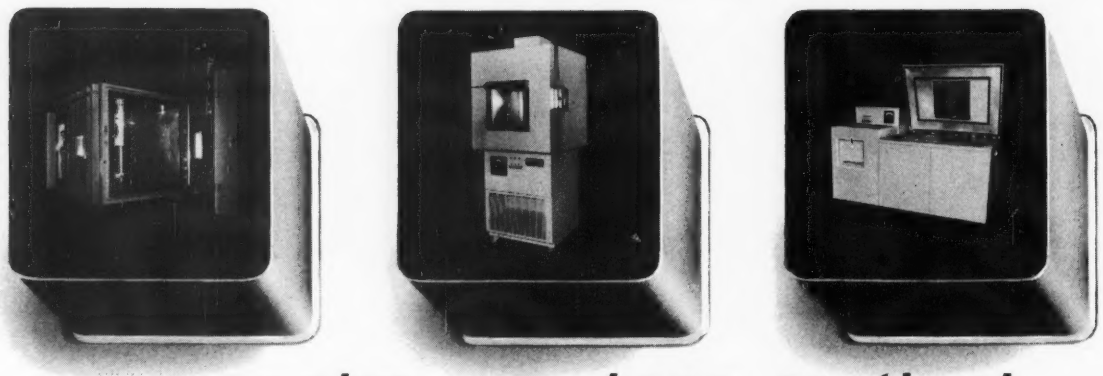
- 100,000 PPH Fuel Flow
- 1,500 PSI Fuel Pressure
- 500°F Fuel Temperature
- 1,000°F Ambient Temperature



PROPULSION TEST FACILITIES, INC.



Tenney push-button environments



. . . any size, any shape, anytime!

No matter what environmental test chamber you need, this much is certain: Tenney either has it in stock or can adapt one of its proven prototypes. From chambers that could house a family of four, down to refrigerator size (and everything in between), you're sure to find the modern, push-button unit you need.

Altitude, temperature, humidity, explosion, sand, dust, fog—just about every punch nature can throw—can be simulated, either alone or in combination. And you get accurate simulation, complete control and precise measurements every time.

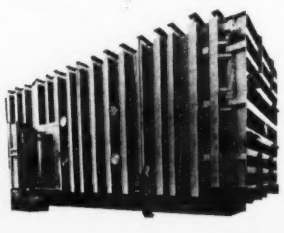
For a complete catalog, describing the entire line, write today to Tenney—the world's largest, most experienced creator of environmental test equipment.

Ask about Tenney's research and development, engineering consultation and design services.

Tenney
ENGINEERING, INC.

1090 SPRINGFIELD ROAD, UNION, N. J. • PLANTS: UNION, N. J. AND BALTIMORE, MD.

OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT



L. C. MILLER COMPANY

New Production Vibration Tester featuring Lateral Controlled Motion

The LCM 1200 series Vibration Systems are completely self-contained within small portable consoles. Designed primarily for production testing of small components they are semi-automatic and simple to operate. Available in either of two sweep frequency ranges 5 CPS to 5000 CPS or 20 CPS to 20000 CPS with 50 force-pounds rated output.

VIBRATION EXCITER

The Vibration Exciter is the LCM 100 which features a horizontally moving push pull driven table. The shaker table is supported by air bearings which stiffly confine movement of the table in all directions but the axis of excitation. This new air suspension system eliminates troublesome springs and flexures; and reduces crosstalk, a major problem with many shaker systems, to an exceptionally low value.

"Heavy" specimens are easily handled as the weight of the table and specimen is supported by air pressure normal to axis of excitation.

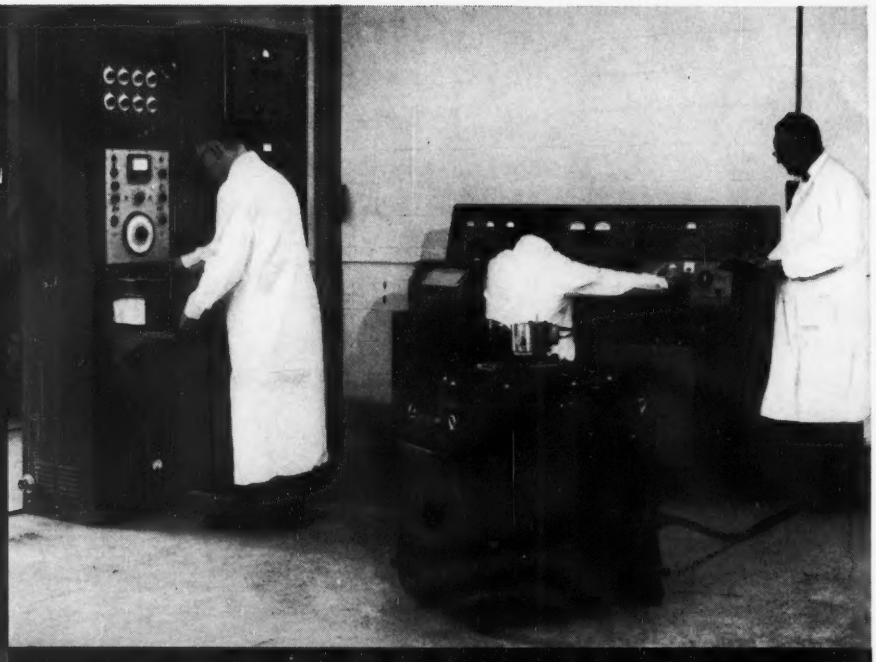
For a System designed to your requirements or for additional information please contact:

LCM division **L.C. MILLER COMPANY**

5005 EAST SLAUSON AVENUE, LOS ANGELES 22, CALIFORNIA · LUdlow 3-1065 · LUdlow 1-0831

Manufactured under exclusive license from International Electronics Research Corporation, Burbank, California.

ENVIRONMENTAL TESTING PROBLEMS ?



SINUSOIDAL and RANDOM VIBRATION
(5 TO 5000 CPS FROM -120°TO +600° F at 200,000 FT. ALTITUDE)
(WITH AUTOMATIC CONTROLLING, PROGRAMMING AND RECORDING)

HIGH INTENSITY ACOUSTIC NOISE
(WITH DIRECT RECORDING)

HIGH-LOW 1200°F TO -120°F TEMPERATURES
(AT ALTITUDES TO 200,000 FEET)

MISSILE SHOCK ACCELERATION TESTING
(SAWTOOTH - SINEWAVE - SQUAREWAVE)

SALT SPRAY • FUNGUS • EXPLOSION
SAND & DUST • HUMIDITY • RAIN • SUNSHINE
ROTARY ACCELERATION • SHIELDED ROOM FACILITIES

QUALIFIED PERSONNEL

RESEARCH · DEVELOPMENT · DESIGN · TESTING · ITEMLAB

ITEMLAB FACILITIES EXCEED ALL MILITARY AND COMMERCIAL SPECIFICATIONS KNOWN TO THE PRESENT ART.

ITEMLAB INC.

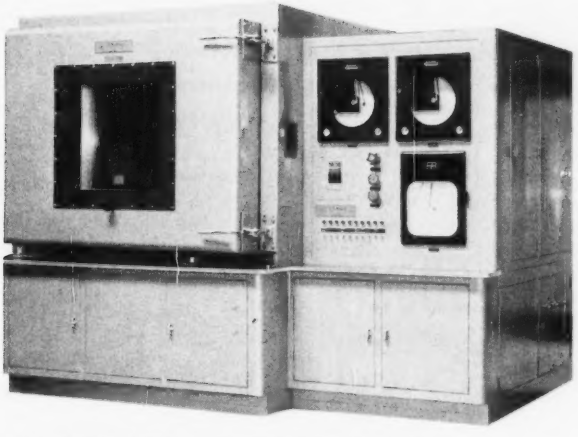
The Nation's Most Complete Environmental Testing Laboratory

PORT WASHINGTON, NEW YORK PO 7-8420-1

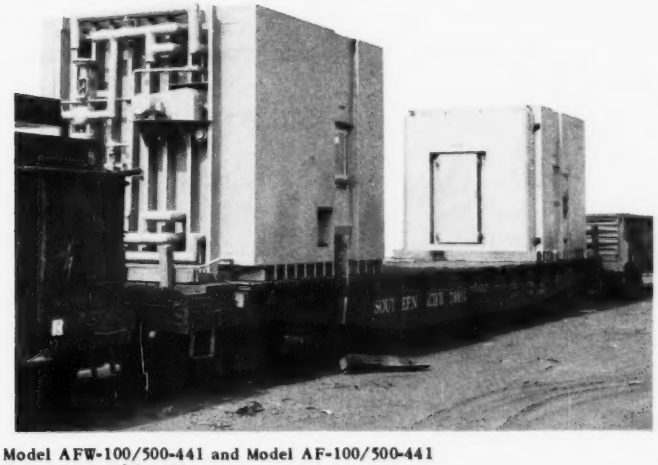
ALTITUDE AND VACUUM CHAMBERS

BEMCO

A-Series



A typical altitude temperature chamber. These are particularly suitable for general work and are available in many ranges. The one shown is an AFW-100/500-36. The vacuum pump and control accessories are mounted in the base.



Model AFW-100/500-441 and Model AF-100/500-441
Being prepared for shipment

These chambers include windows, automatic door operators, and many other special features to suit the customers needs.

ALTITUDE AND VACUUM CHAMBERS

Vacuum and altitude simulation chambers are used to solve many research, development, and production problems. Bemco chambers meet the most exacting performance specifications.

Altitude chambers are manufactured in the tank and rectangular types with or without automatic control. Temperature control and programming can be provided even under high vacuum conditions. Sizes range from bench mounted one cubic foot models to walk-in rooms.

Bemco Inc. is constantly pushing the performance of environmental chambers to higher limits. Vacuum in the 10^{-6} mm Hg. range are standard. High vacuum equipment is now practical for laboratory or production shop.

Pumping systems employing diffusion pumps and cold traps have been developed with control systems that require very little operator skill.

Bemco Inc. develops, designs and manufactures a complete line of environmental equipment for simulating altitude, vacuum, pressure, temperature, humidity, salt spray, sand and dust, sunshine, rain, explosion and other conditions. Further details will be sent on request.

BEMCO INC. • 11631 Vanowen Street • North Hollywood, California

TRiangle 7-5339 POplar 5-2165

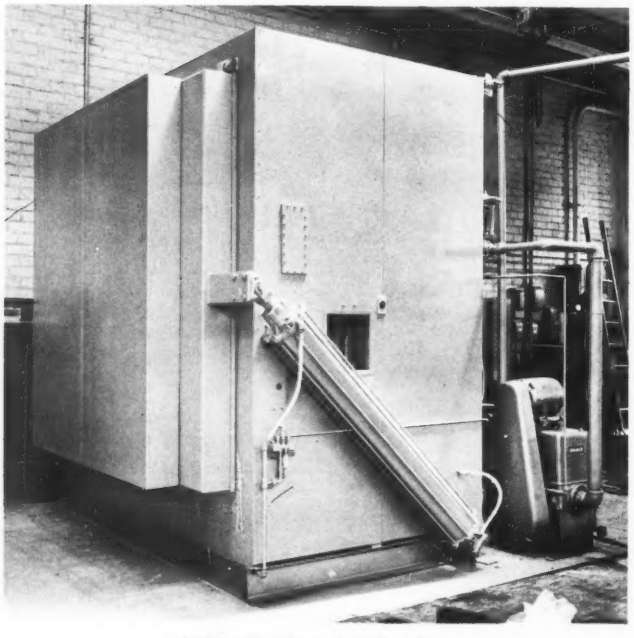
REPRESENTATIVE IN YOUR AREA FURNISHED UPON REQUEST

HIGHER, FASTER, HOTTER . . .

Convair uses a 1200° INRECO Altitude Chamber to test missile and plane components which must withstand high temperatures at high altitudes.

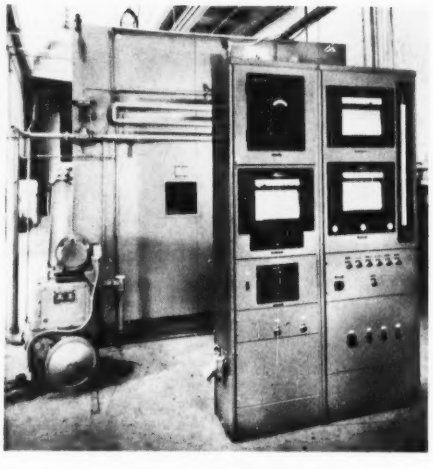
Control of the oxygen content of the air in the Chamber, protects laboratory personnel against the dangers involved in testing inflammable materials at high temperatures.

A unique feature of the temperature control system is the use of a Royson Curve follower for programming temperatures.



1200 °F Altitude Chamber

6' x 5' x 4' Test Space
Temperature 100° to 1200 °F
Altitude 100,000 feet
Program Control
Oxygen Indication
CO_2 Injection



The services of INRECO engineers are available to help you with special problems in the design of environmental test equipment.

INRECO

INDUSTRIAL REFRIGERATION CO., INC.
8940 ELLIS AVE., LOS ANGELES 34, CALIF. ● UPTON 0-6664

ENVIRONMENTAL TEST CHAMBERS

SOUND-INDUCED VIBRATION

BY
PRESTON W. SMITH, JR.
AND MIGUEL C. JUNGER

CAMBRIDGE ACOUSTICAL ASSOCIATES
CAMBRIDGE, MASSACHUSETTS

There is a widely circulated story, which one occasionally encounters in old-fashioned texts on acoustics, about a soprano who broke a wine-glass by singing a sustained note fortissimo. This early case of structural failure by sonic fatigue was produced with a sound power which is negligible compared to those generated in modern technology. The 30 milliwatts radiated by the soprano are indeed trivial compared to the 1 kw of sound power produced by the DC-3 and the 5000 kw generated by the engines of an intercontinental ballistic missile. Curiously enough, the soprano's feat need not deter a test engineer from having a sip of wine while on the job, as the wine-glass might well survive intact in the vicinity of an engine test stand. The reason for this is that jet and rocket engines spread their acoustic output rather evenly over the whole audible spectrum. Furthermore, the pressure fluctuations associated with any one frequency component are not sustained, but occur at random. The soprano, on the other hand, concentrated all her acoustic power at one frequency, which happened to be one of the natural frequencies of the glass, and she sustained the note sufficiently long to allow large amplitude, resonant vibrations to build up. It is also probable that she had selected a glass whose fatigue strength had been lowered by residual thermal stresses.

However, in spite of the less efficient use engines make of their acoustic power, fatigue failures do occur, particularly in thin panels whose fatigue strength has been lowered by various stress raisers, such as rivets. These failures occur as a result of pressure amplitudes of the order of 0.1 psi, i.e., of loads which seem insignificantly small compared to the inertial and aerodynamic loads the structure is designed to withstand. Such small pressure fluctuations can produce fatigue failures only by giving rise to a near-resonant response in the panel, and by accumulating an impressive number of stress cycles in an operating time which is far shorter than the test periods usually associated with fatigue failures. Thus, for a 1000 cycle per second noise component, the 10 million stress cycles usually associated with the endurance limit are reached in less than three hours.

In spite of these factors, actual fatigue failures as a result of sound-induced vibrations are relatively rare. A more common type of structural damage encountered in electronic equipment results from collision between vibrating elements, for example, a vacuum tube grid and its plate. Finally, intense sound may produce operational failures or malfunctioning in sensitive equipment, particularly

electronic devices, as a result of acoustically induced vibrations. This is the damage most frequently caused by noise.

In this paper we shall summarize various analytical results from which estimates can be made of the mechanical response to a sound wave. First we consider the major characteristics of the noise produced by aircraft and jet engines. (Other industrial noise sources are not powerful enough to cause mechanical damage.) A description is given of the resulting mechanical response of structures, both a lumped system that moves as a unit and a distributed system. Finally, the response of structures to excitation by a noise with continuous spectrum is discussed.

The Sound Field[2, 3]

The sound field is characterized (1) by the amount of acoustic power involved, (2) by its frequency spectrum, i.e., the distribution of this power over the audible range, and (3) by its directivity pattern, i.e., the angular distribution of the acoustic power. In a jet plane or missile the principal sound source is associated with the turbulence generated by the hot exhaust gas emerging from the engine nozzles. The compressor of a turbojet engine creates a whine or screech which is noticeable only at idle conditions when noise from the exhaust is small. This sound is also radiated only into a very narrow cone to the front of the engine; it can generally be neglected. The exhaust noise generally has a continuous spectrum. The high frequency components are generated very close to the nozzle while the low frequency components originate downstream as far as 10 or 15 nozzle diameters. Occasionally, with afterburner and in choked jets, discrete frequency sounds are generated. These noise components are not important in the present-day turbojet operating at military power.

In modern turbojets and rockets a quite significant amount of the kinetic energy of the exhaust gases is converted into sound energy. If one thinks of a jet as a sound source, (although that is a defeatist's attitude), the ratio of sound power to the jet stream power can be considered an efficiency. Measurements show that this efficiency is about 1 percent in high velocity jets (Fig. 1). For low velocity jets, the efficiency is much poorer, varying with the fifth power of the jet velocity. The effect of the ratios of jet density p and temperature T to ambient density and temperature is also shown in Figure 1. A J-57 turbojet, operating at military power, produces about 14 kilowatts of sound power which spreads out in all directions so that the sound pressure falls off inversely with distance.

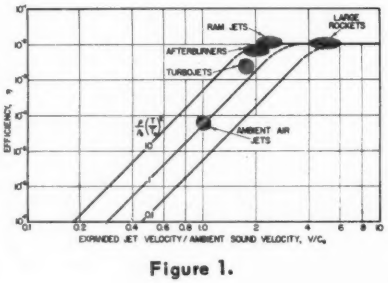


Figure 1.

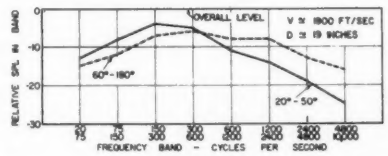


Figure 2.

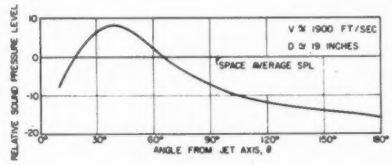


Figure 3.

The second characteristic of the jet sound field is the frequency spectrum shown in Figure 2. The labels identifying the two curves in this figure refer to the angle between the jet axis (to the rear) and the radius from the nozzle to the point where the sound intensity is measured. It is seen that the low frequency components are somewhat more prominent close to the aft direction (20-50 degrees) than in the forward and broadside directions (60-180 degrees). The differences are however slight. Essentially, the jet radiates sound energy over the whole audible spectrum, in all directions, with sufficiently constant distribution of energy to discourage attempts at avoiding resonance by shifting the natural frequency of the structure.

The angular distribution of the sound energy from the jet is shown in Figure 3 which gives the sound pressure in any direction relative to the average sound pressure, averaged over a spherical surface.

However, within about 100 ft. of a turbojet where the most intense noise is found, the sound power no longer follows the inverse-square law dependence on distance and the distribution of pressure amplitude with angle begins to depend on distance from the jet nozzle. In this so-called near field, the spatial variations of sound pressure are therefore different than those given in the previous curves. Figure 4 shows contours of sound pressure level, in decibels, as observed with engines like the J-57. Distances are expressed in terms of the jet nozzle diameter. Note that sound pressure levels of 150 db, about 0.1 psi, occur at a point 14 nozzle diameters aft and 5 diameters to the side of the exit. Pressure levels of 140 db – a value we will use in an example later – extend to a distance of about 33 diameters, or more than 50 ft. with a J-57. The large rocket engines, in which the jet velocity is considerably greater, create sound pressures exceeding those in Figure 4 at comparable distances.

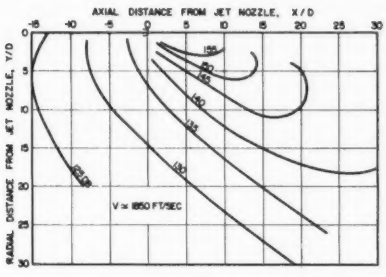


Figure 4.

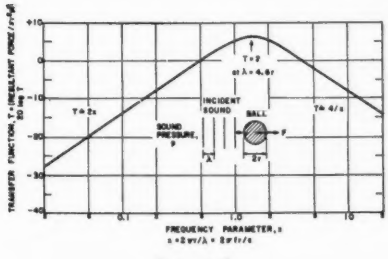


Figure 5.

Net Accoustic Force on a Body[7]

Let us now turn from the sound field to consider the action of this sound on elastic structures. However before introducing the effect of elasticity, we will determine the force exerted by the sound waves on a rigid structure. The sound pressure is a modulation of the atmospheric pressure. With a pure tone, it varies sinusoidally in time and in space. For a spectrum component of frequency f, the wavelength, which describes the variation of the sound pressure in space, is approximately equal to (1100/f) feet. Referring to the spectrum in Figure 2, we note that an extended structural element, such as a panel, will in most part experience sound pressures which are not uniform over its area. Only the pressures associated with components near the low frequency end of the spectrum will be uniform. On the other hand, small electronic components will experience essentially uniform sound pressures except for the less intense frequency components near the upper end of the spectrum.

To illustrate the effect of the relative sizes of the element and of the wavelength, consider a sphere mounted on a rigid rod, and exposed to a propagating plane wave. Even though this geometry is quite different from shapes encountered in practice, it will allow us to reach certain general conclusions. The force exerted by the wave on the sphere is oriented along the direction of propagation of the wave. In Figure 5 the net force on the sphere is plotted as a function of the ratio of sphere's circumference to the wavelength. The resultant force is normalized to the product of sound pressure amplitude of the incident sound by the spherical cross section. The ratio is called the *transfer function* since it describes the transfer of force from the sound field to the mechanical structure.

For small values of the abscissa, the sound pressure acts more or less uniformly over the whole surface of the sphere. The resultant force on the sphere is therefore small. For large values of the abscissa, the sphere can be subdivided into zones of alternating positive and negative sound pressures. Again, the resultant force is small, because the forces from these zones tend to cancel. Quite a different situation exists in the middle range when the diameter of the sphere is of the same order of magnitude as the half-wavelength. In this case, the sound pressures on opposite sides of the sphere are of opposite sign, and therefore give rise to a large resultant force.

The results presented in this graph can be extended to a system which is a more realistic representation of certain practical structures, such as vacuum tubes. This system is a hemisphere set on a baffle or flat plate. It can be shown that the net tangential force exerted on the hemisphere by a sound wave approaching from a direction making an angle θ with the normal to the baffle is equal to the force plotted in Figure 5 multiplied by sin θ. As a matter of fact, the action of a sound wave on a structure of any shape follows the trend embodied in Figure 5 fairly well. In essence, the general conclusion is that the resultant force is small except when the dimension of the structure is of the same order of magnitude as the half-wavelength of of the incident sound wave. One may therefore expect that structural panels will only be affected by low frequency components, at least with regard to their fundamental mode, and vacuum tubes only by very high frequencies.

Resonant Response[7]

Let us now construct a more realistic model by assuming that the sphere is mounted on a flexible rod, forming a single degree of freedom system. This system has a natural resonance, and its response to alternating forces at or near the resonant frequency will be large. The amount of resonant amplification is determined by the damping in the system and has a maximum value at resonance which we will call Q.

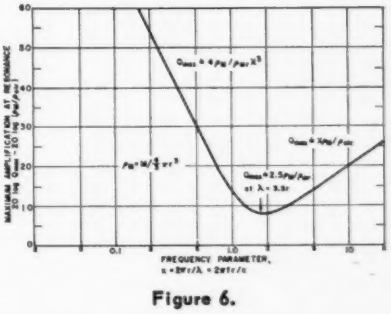


Figure 6.

When the excitation is a sound wave, the motion of the sphere is not only limited by the mechanical damping inherent in the system, but also by damping action due to the sound energy the sphere radiates as it oscillates. When the inherent mechanical damping of the system is small this acoustic damping action, known as damping, may determine the extent of resonant amplification. The maximum resonant amplification Q which

a system can have, no matter how small is the mechanical damping, is plotted in Figure 6 as a function of the familiar parameter, ratio of circumference to the wavelength. The Q has been divided by the ratio ρ_M/ρ_a of average density of the sphere to the density of the atmosphere, and plotted on a logarithmic scale. In general, radiation damping is a negligible effect unless the mechanical structure is very lightweight and almost without losses. For those cases where it is important, it is fortunate that the smallest values of resonant amplification occur in precisely that frequency range where the exciting force exerted by the sound wave is largest.

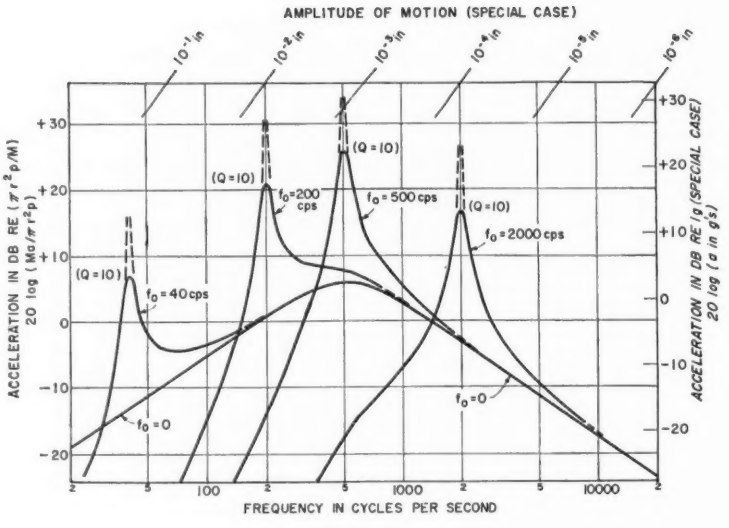


Figure 7.

The results obtained so far show that the familiar frequency response curve of a damped, single degree of freedom system must be modified in the case of sound-induced vibration to account for the variation with frequency of the damping action (Fig. 6) and the excitation (Fig. 5). How these various effects combine is illustrated in Figure 7 which shows the frequency response curve of a 1 ft-diameter, elastically mounted sphere set into vibration by a sound wave. The response is expressed as the ratio of the acceleration of the sphere to the steady acceleration it would experience under the effect of a steady force equal to the product of sound pressure by spherical section. The ordinate on the right gives values of acceleration relative to 1g for a special case: sound pressure level of 140 db, spherical mass of 5 lb. Response curves have been plotted for various systems having different natural frequencies.

The extremely important conclusion to be drawn from these curves is that a particularly critical condition is likely to develop when the natural frequency of thr system lies not too far from the frequency which corresponds to a maximum of net force from the sound wave (Fig. 5). Hence, while shifting the natural frequency of a system exposed to white noise will not be effective in promoting a non-resonant condition, it may be advantageous if it prevents this critical situation.

However the designer must be careful to analyze the problem in detail when trying to reduce the resonant response by shifting the natural frequency. If he lowers the natural frequency by simply adding mass, he also increases the resonant amplification factor Q of the system. The result may not be an improvement. In fact, it can be shown from Figures 5 and 7 that the acceleration at resonance is not affected by changes in mass unless the resonant frequency is below the frequency where the net acoustic force is a maximum (Fig. 5). For lower frequencies, adding mass will reduce the acceleration at resonance.

Force on a Distributed System[6]

The conclusions we have drawn for single degree of freedom systems are qualitatively valid for distributed systems as well. Nevertheless it is interesting to consider more exactly a representative distributed system, namely a flat plate.

The general motion of the flat plate is ordinarily described as a simultaneous combination of motions in the various natural modes. The modes are distinguished by the number of internal nodes, between the end supports, at which there is no motion. Each mode has a characteristic generalized mass and generalized stiffness, and the amplitude of modal response at different frequencies follows the same rules that govern a single degree of freedom system.

However the generalized force – the driving force for the mode – resulting from the incident sound wave is different for different modes. A transfer function can be defined, in the same way as in our previous example of a sphere, which relates the generalized force for the mode to the sound pressure. In the previous example, the value of the transfer function depended upon the relative size of the wavelength of sound and the diameter of the sphere. For the flat plate we must consider the *trace wavelength* which is the projection of the true wavelength onto the plane of the plate.

If the true wavelength is λ and the angle of incidence of the sound wave is θ, measured from the normal, then the trace wavelength is given by:

$$\lambda' = \lambda/\sin\theta.$$

The trace wavelength is the distance on the plate between the successive points of maximum positive sound pressure.

The transfer functions for the various modes of a flat plate of length L are shown in Figure 8. The vertical scale indicates the ratio of the modal generalized force to the product of the area of the vibrating plate by the sound pressure of the incident wave. The horizontal scale gives the ratio of the length of the plate to the trace wavelength of sound. (It is assumed that the plate is rectangular, is simply supported at its edges in a larger plate, and that the sound propagates in the direction of the long side.)

Small values on the horizontal scale may correspond either to low frequencies or to small angles of incidence (near normal). If the frequency is held constant and the angle of incidence varied from normal (0°) to tangential (90°), the value of the abscissa increases from zero to a finite maximum value.

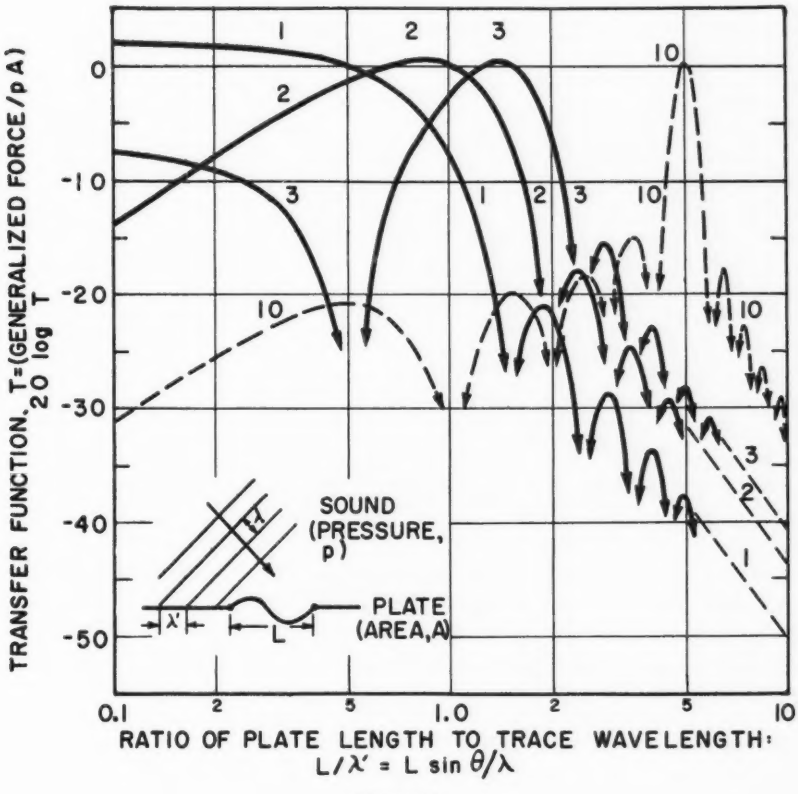


Figure 8.

The fransfer function for the fundamental or first mode, where the whole plate moves in phase, is relatively constant until the trace wavelength is about as large as the length of the plate. Beyond that point the coupling is poor. For all the higher modes, the coupling is poor both at low and high values of the abscissa. The transfer functions for these higher modes are characterized by a peak where the trace wavelength is equal to the wavelength of mechanical motion, that is, where

$\lambda' = 2L/n$, in the case of the n-th mode.

These peaks become very sharp in the highest modes as is shown by the results for the 10th mode (Fig. 8).

As mentioned previously, the curve for response motion of the plate, in any one mode, is given by the product of the transfer function by the usual dynamic response curve of a single degree of freedom system. The dangerous condition is one in which good coupling, represented by a peak in the transfer function, coincides with mechanical resonant amplification. In general, it is difficult to avoid that situation in the lower modes of vibration.

A rule-of-thumb describing the most undesirable condition of coupling may be useful in assessing the vibration resulting from sound. Note that the maximum value of the transfer function T (Fig. 8) is about unity (0 db) except in the fundamental mode where it is 1.25 (+2 db). Now, in the case of direct mechanical driving of the plate at the position of maximum amplitude of motion in any mode, the generalized force is just equal to the applied force. Therefore we can say that the response to the sound wave in any one mode is no worse than it would be if a concentrated force, equal to the product of sound pressure and plate area, were to act at the point of maximum motion.

Response to Noise Signals

The previous discussion has been directed toward the response to a single-frequency sound wave. In the

case of jets and rockets the acoustic excitation is noise with a continuous but not constant distribution of energy in frequency. The description of such a signal or of the response has to be phrased in statistical terms, in terms of a spectrum.

However, the present results can be used directly to find the response spectrum from the sound spectrum by means which are standard in problems of random mechanical vibration. The power spectrum of the response is known to equal the product of the power spectrum of the input by the square of the frequency response function.[1] This same rule applies to vibration induced by sound. It is only necessary that the usual mechanical response function be multiplied by the transfer functions that we have been discussing.

Sometimes a comparison is desired between the resonant response to excitation by a pure tone and the overall response to a broad band of noise. A simple comparison can be made if a number of restrictive conditions are satisfied by the experimental set-up.

First, the angles of incidence of the two sounds upon the structure should be the same. This is necessary because of the influence of the angle upon the coupling (Fig. 8).

Secondly, the major part of the response has to be near the mechanical resonant frequency so that the structure can be considered as a single degree of freedom system.

Third, we shall assume that the noise spectrum is relatively flat near the resonant frequency. This is usually the practical situation.

With these simplifying assumptions, we can compare the relative magnitudes of noise and of pure tone at resonance required to produce the same rms response.[4, 5]

The result is:

$$p_t^2 \doteq f_o [p_n(f_o)]^2 [\pi/2Q]$$

where

p_t is the rms sound pressure of the pure tone;

$p_n(f)$ is the rms sound pressure per 1 cps band of the noise; that is, p_n^2 is the spectral density of the noise;

f_o is the resonant frequency;

Q is the maximum resonant amplification.

In acoustics, a noise is usually specified by the rms sound pressure in frequency bands one octave wide, which we will write here as $p_n(\text{octave})$. For flat spectra the conversion only involves the width of an octave band in cps: $2^{1/2} f_o$. Thus, we can say, approximately,

$$[p_n(\text{octave})]^2 \doteq 2^{1/2} f_o [p_n(f_o)]^2.$$

The combination of these equations is a new relationship:

$$p_t^2 \doteq [p_n(\text{octave})]^2 [\pi/2^{1/2}Q].$$

The interpretation of this result is the following. With lightly damped structures, the sound pressure of a pure tone can be much less than the octave-band sound pressure of noise and still create the same rms response. For example, with a resonant amplification Q of 10 the responses will be the same if the pure tone sound pressure level is 6.5 db less than the octave-band noise level.

Conclusion

The progress of civilization leads us from the pure tones of the soprano to the raucous bellow of intercontinental missiles. But the manner in which these sounds induce mechanical vibration remains the same. Mechanical resonance – resonant amplification – is usually a prerequisite to large response. When the excitation is accoustical rather than mechanical, it is further necessary to consider the degree of coupling between the sound wave and the response motion. This coupling is expressed by *transfer functions* whose values are dependent upon the relative size of acoustic wavelength and structural dimensions. In other regards, the problems are familiar to mechanical engineers.

References and Selected Bibliography

1. S. H. Crandall, "Statistical Properties of Response to Random Vibration," *Random Vibration*, ed. Crandall (The Technology Press, Cambridge, 1958), chap. 4.

2. P. A. Franken, "Review of Information on Jet Noise," Noise Control *4*, 152 (May 1958).

3. H. E. von Gierke, "Aircraft Noise Control," *Handbook of Noise Control*, ed. Harris (McGraw-Hill Book Company, Inc., New York, 1957), chap. 33.

4. L. W. Lassiter and R. W. Hess, "Calculated and Measured Stresses in Simple Panels subject to Intense Random Acoustic Loading," WADC Technical Note 4076, September 1957.

5. J. W. Miles, "On Structural Fatigue Under Random Loading," J. Aeronautical Sci. *21*, 753 (November 1954).

6. A. Powell, "On the Response of Structures to Random Pressures and to Jet Noise in Particular," *Random Vibration*, ed. Crandall (The Technology Press, Cambridge, 1958), chap. 8.

7. P. W. Smith, Jr., "Sound-Induced Vibration," Noise Control *4*, 352 (November 1958).

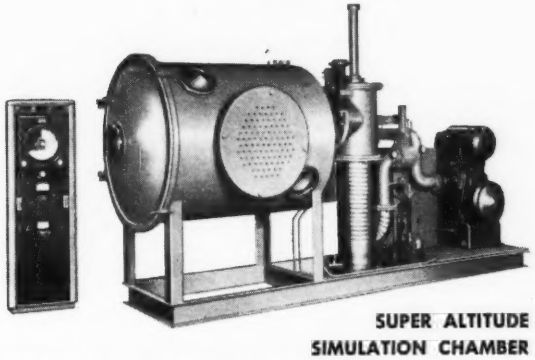
everyone talks about

"RELIABILITY"...

MURPHY & MILLER

BUILDS IT!

Long before "reliability" became the magic word in describing every conceivable type of equipment, Murphy & Miller was building environmental test equipment that delivered reliability in terms that could be measured: CONTINUOUSLY ACCURATE PERFORMANCE UNDER THE MOST RIGOROUS OPERATING CONDITIONS. (We will always build reliability into everything that bears our name.)

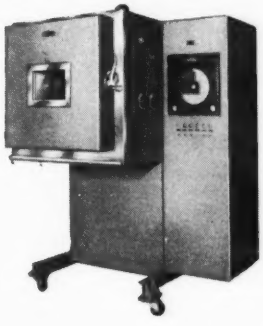


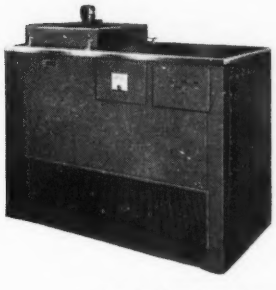
SUPER ALTITUDE SIMULATION CHAMBER

- Sea Level to 350,000 ft. (760 MM Hg to ½ Micron)

COMBINED TEMPERATURE and VIBRATION SIMULATION TEST CHAMBER

- Sizes 1 to 64 cubic feet
- Temperature Range: —120°F. to +500°F
- ALL STAINLESS STEEL TEST SPACE
- Optional Recording, Controlling, and Programming Equipment Available
- Self Elevating Chamber Available (Optional)





COLD TEST CHAMBER

- Temperatures to —200°F
- Stainless Steel Test Space
- Forced Air Circulation
- Heating cycles available to 300°F
- Test space capacities start at 1 cu. ft.

For the *best* in environmental test equipment, check Murphy & Miller first. Write for illustrated circular.

murphy & miller, inc.

620 West Taylor Street • Chicago 7, Illinois

Engineering Representatives In All Principal Cities

MEMBER OF ENVIRONMENTAL EQUIPMENT INSTITUTE

OPERATIONAL TESTING under all ENVIRONMENTS

Use our facilities to evaluate product operation under all environmental conditions. Get automatic alternating cycles of contrasting conditions...remote control of product operation by mechanical, electrical or hydraulic means... and a wide range of supply voltages and frequencies. Simulate high-low temperatures, humidity, altitude, explosion, immersion, salt spray, sand and dust, rain, fungus, vibration, shock, acceleration, etc. Test to military, government and commercial specifications.

Complete facilities in the fields of chemistry; metals chemistry; metallurgy; physical testing of materials; engineering analysis of mechanical, electromechanical and electronic devices; site inspection; package testing; psychometrics and certification services for product quality control.

UNITED STATES TESTING COMPANY, INC.

1515 Park Avenue, Hoboken, N. J.

Branch Laboratories:

BOSTON • BROWNSVILLE • DALLAS • DENVER • LOS ANGELES

MEMPHIS • NEW YORK • PHILADELPHIA • PROVIDENCE • TULSA

V. A. SNYDER CO., INC.

Engineering Representatives

ESTABLISHED 1945

Specializing in all types of Environmental Test Equipment

For Prompt Service, Please Contact Your Local Sales Office

Metropolitan New York and Northern New Jersey

P.O. Box 184, Union, N.J. MUrdock 8-6100

Eastern Pennsylvania, Southern New Jersey and Delaware

1424 Race St., Philadelphia 2, Pa.

WALNUT 2-0634

DESIGN OF AN IMPROVED OPTICAL SYSTEM for High Frequency ACCELEROMETER CALIBRATION

L. E. HAYES
RESEARCH ENGINEER
ENVIRONMENTAL LABORATORY
AUTONETICS
DIVISION OF NORTH AMERICAN AVIATION INC.

CONCLUSION

SYSTEM PERFORMANCE

After completing the assembly of the calibration system, it was thoroughly tested to determine the systems limitations. Various sources of errors were investigated and magnitudes of such errors evaluated. The following paragraphs describe the test results.

PERFORMANCE OF THE ELECTROMECHANICAL VIBRATOR WITH ITS DAMPER SYSTEM AND COOLING SYSTEM

Earlier in this report it was noted that micrometer microscope techniques for measuring displacement amplitudes in the micro-inch ranges were useless without the use of some device to remove the transients from the vibrator table motion. The damper now being employed was found to be exceptionally effective in removing these transients as well as the residual 60 cps excitation. A comparison of Figure 9A and 9C gives a graphic picture of this effectiveness. Figure 9A is a microphotograph of the optical slit without excitation while using the damper. Figure 9C shows the same slit without excitation but with the damper removed. While Figure 9A shows a clear clean slit image, the image shown in Figure 9C is indistinct and considerably broadened.

Frequency response tests performed on the damper indicate the system is effective for all frequencies between 75 and 3000 cps. Because of vibrator limitations it was impossible to test and damper above 3000 cps. Below 75 cps vibrator table transient motion was noted in the slit excursion. A plot of frequency vs transient motion of the vibration table with excitation is shown in Figure 11A. When this curve is compared with that for the undamped motion in 11B the damper efficiency is again graphically illustrated.

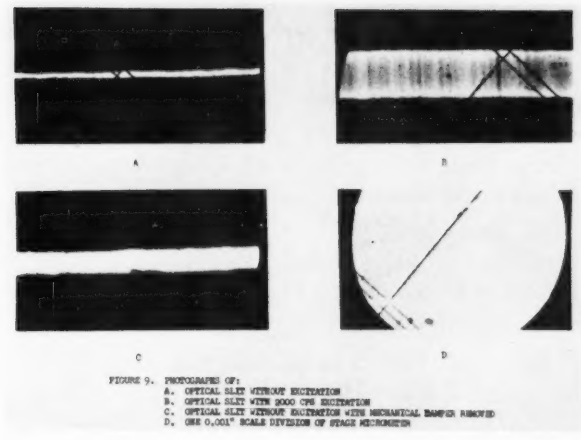


FIGURE 9. PHOTOGRAPHS OF:
A. OPTICAL SLIT WITHOUT EXCITATION
B. OPTICAL SLIT WITH 2000 CPS EXCITATION
C. OPTICAL SLIT WITHOUT EXCITATION WITH MECHANICAL DAMPER REMOVED
D. ONE 0.001" SCALE DIVISION OF STAGE MICROMETER

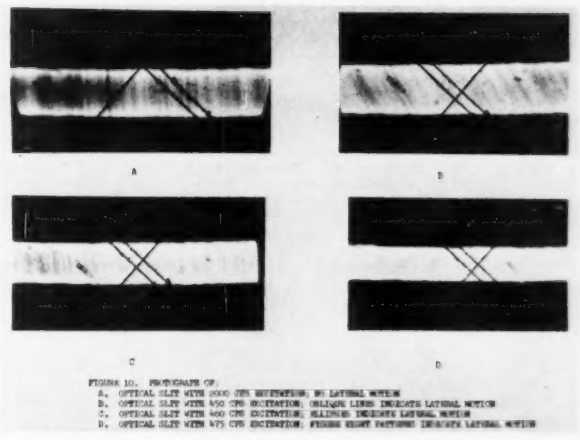


FIGURE 10. PHOTOGRAPH OF:
A. OPTICAL SLIT WITH 2000 CPS EXCITATION, NO LATERAL MOTION
B. OPTICAL SLIT WITH 450 CPS EXCITATION, OBLIQUE LINES INDICATE LATERAL MOTION
C. OPTICAL SLIT WITH 460 CPS EXCITATION, BLURRING INDICATES LATERAL MOTION
D. OPTICAL SLIT WITH 475 CPS EXCITATION, FUZZINESS INDICATES LATERAL MOTION

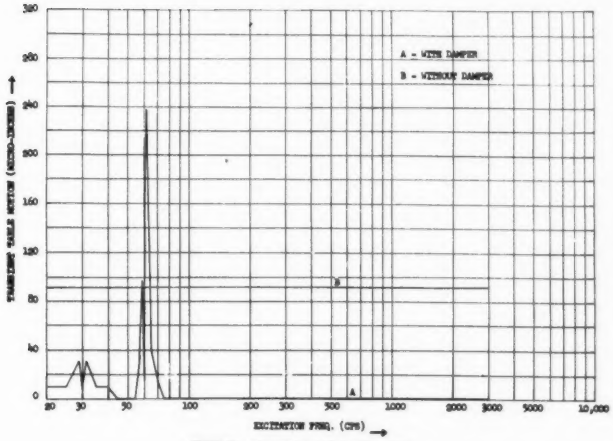


FIGURE 11. VIBRATOR TABLE TRANSIENT MOTION

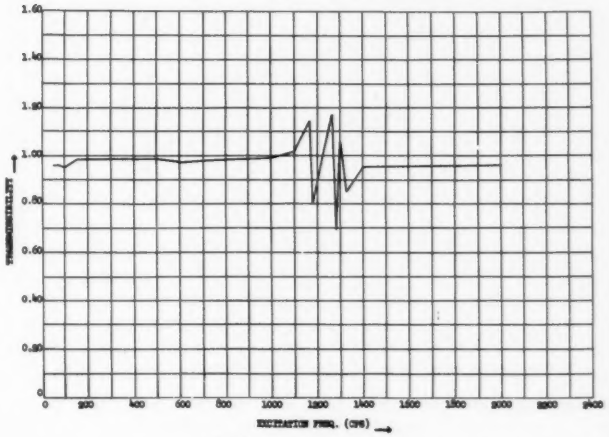


FIGURE 12. MICROSCOPE SLIT DRIFT

During initial testing of the calibration system, the slit image in the microscope was noted to experience a gradual drift toward the top of the microscope field. This drift measured approximately 0.00002 inch per minute. Further tests proved that this drift was due to temperature changes experienced by the vibrator table and slit fixture. Computation shows that, if the vibrator table and slit fixture experience a temperature change of only 0.2 °F per minute, the observed drift would result. Since such drift would make accurate displacement amplitude measurements impossible, the cooling system described previously was devised.

When using the cooling system, an initial temperature stabilization period greater than 1.5 hours must be observed. After the stabilization period has elapsed, the observed drift of the slit image becomes less than 0.25 micro-inches per minute. Since a displacement amplitude measurement requires approximately 20 sec., the slit drift during a given displacement amplitude measurement is far less than the resolution limit of the system and thus can be ignored. In Figure 12A a plot is shown of slit drift vs time while using the cooling system. The effectiveness of the cooling system is shown by comparing Figure 12A with 12B where no cooling system was employed.

Thus by employing the damper and cooling system with the MB-C-11-C Vibrator a system with adequate stability for accurate displacement amplitude measurements at excitation frequencies ranging up to 3000 cps has been developed. There appears to be no reason why similar damper and temperature control systems could not be effectively employed with other types of vibrators.

MICROMETER MICROSCOPE PERFORMANCE

Performance limitations of the micrometer microscope are defined in terms of systematic errors, random or observational errors, and ease of operation. To minimize systematic errors, an accurate and simple calibration procedure is employed. Since the displacement amplitude measurements are dependent only on the act of positioning the hair lines on the slit excursion limits, the only calibration required is for the scale associated with the micrometer screw which controls the hairline motion. To facilitate greater ease in positioning the cross hairs on the slit excursion limits, the bifilar screw micrometer frame containing the cross hairs was turned about the optical axis of the microscope until the fixed and movable hair lines each formed an angle of approximately 45° with the slit excursion limits. The orientation angle is not critical but must remain constant after the calibration is complete. To prevent any angular motion of the bifilar micrometer, the micrometer frame was rigidly clamped in position following the original hair line orientation. Figures 9 and 10 exhibit various microphotographs in which the hair line orientation is evident.

Following the hair line orientation, the microscope calibration was begun by focusing the microscope on a stage micrometer with 0.001 inch scale divisions which was previously accurately calibrated to ±0.000005 inch with a slide micrometer and mikrokator. The number of bifilar scale divisions required to move the movable cross hairs through one scale division on the stage micrometer was counted. Figure 9D shows a typical scale division. To remove reading errors ten complete measurements were made on each of three calibrated stage micrometer divisions. Finally, the bifilar scale factor expressed in micro-inches/scale division was computed for each of the three sets of data. A sample of the calibration data is shown below in Table I.

TABLE I

Sample Calibration Data for Microscope

Slide Micrometer Measurement of Stage Micrometer Division (mm)	Bifilar Micrometer Measurement of Stage Micrometer Division (Bifilar Scale Divisions)
0.0254	3413
0.0253	3415
0.0253	3411
0.0253	3414
0.0254	3417
Ave. = 0.02534 mm	Ave. = 3414
= 0.000996 inch	

$$\text{Calibration factor} = \frac{0.00099 \text{ inch}}{3414} = 0.2915 \text{ micro-inches per division}$$

The calibration data and results show an average value of 0.292 micro-inches per scale division with maximum and minimum scale factors differing by approximately ±0.025 percent. This variation is surprisingly small and is misleading. Because of scale limitations of the slide micrometer used to check the stage micrometer, an error of ±0.1 percent is considered more realistic. These small variations are probably due to random reading errors. Because of the simplicity of the calibration technique there appears to be slight chance of a significant systematic error being present.

When performing a displacement amplitude measurement additional reading or random errors are encountered. After analyzing approximately 100 trial displacement amplitude measurements, similar to those tabulated in Table I, the results indicate that displacement amplitude measurements can be reproduced to ±3 bifilar scale divisions or ±1 micro-inch. Based on these results it is apparent that displacements with 100 micro-inch amplitudes can be measured with ±1 percent error. Because of vibrator limitations, displacements of 100 micro-inch amplitudes are difficult to achieve at excitation frequencies between 3000 and 4000 cps would have greater than ±1 percent error but would be usable.

Figures 9B and 10A microphotographs show typical displacements with approximately 400 micro-inch amplitudes at 2000 cps excitation frequency. These photographs taken with 20 second exposure times, are additional evidence of the excellent stability of the optical system, which makes reasonably fast and accurate hair line adjustments possible. To prevent errors introduced from micrometer screw back lash the hair lines are always moved from the top excursion limit to the bottom limit.

DETECTION OF VIBRATION LATERAL MOTION

Examination of Figures 9B and 10A reveals dark vertical lines in the slit excursion. These lines are due to thickness variations of the original aluminum film deposited on the glass disk. These vertical lines can be used to indicate and in some cases identify the type and measure the magnitude of vibrator lateral motion. When lateral motion is present these vertical lines become straight oblique lines, circles, ellipses, or other more complex geometrical patterns. Examples of such configurations are shown in Figures 10B, C, and D.

EFECT OF PARALLAX

Several people have reported problems with parallax when using micrometer microscopes. Parallax is the relative motion, as the observer moves, of two objects at different distances from the observer. For example, as the earth revolves about the sun, the close stars appear to move in a small circle relative to the more distant background stars. This motion is due entirely to the observers motion. When using a micrometer microscope, if the slit image and hair lines appear to be different distances from the observer, parallax effects will occur when the observer moves his eye position. Thus, to prevent parallax the slit image and hair lines must be placed in the same plane. In the instrument being described this plane is the focal plane of the primary objective. The writer has never observed parallax effects if normal precautions are exercised in focusing the microscope.

DIFFRACTION PATTERNS

When very small optical slits are illuminated, interference patterns or diffraction patterns are observed. Such patterns have been observed in the optical system being described. However, by using the amber filter to achieve better contrast between the slit and its background, and by reducing the light intensity incident on the slit, the diffraction patterns disappear. Diffraction patterns can result from slight defocusing of the slit or hair lines. These patterns can be seen along the hair line in Figures 10B, C, and D where the hair lines are slightly defocused.

ACCELEROMETER OUTPUT MEASUREMENT ERRORS

The errors normally encountered in electronic measurements can be described in terms of random errors or calibration errors. The random errors may be caused by voltage supply line fluctuations, some circuit characteristics, or reading errors. Calibration errors are usually due to aging effects of electronic components and can be removed by proper calibration procedures. The following paragraphs describe possible errors in the accelerometer voltage output measurements.

To prevent effects resulting from supply line voltage variations, all supply voltages are controlled by Sorensen Voltage Regulators. Calibration errors are limited to the basic error of the Calivolter and harmonic distortion analyzer. By frequently checking the Calivolter with a voltage standard its error is maintained within ±0.25 percent. By proper choice of excitation frequencies the harmonic content of the accelerometer output voltage is maintained less than 5 percent. Harmonic distortions of this magnitude introduce approximately ±0.25 percent error. Since the voltmeter is used only to compare two voltages the only error encountered with the voltmeter, is that associated with matching the two voltages. Meter reading tests show that two voltages can be matched to ±0.5 percent when employing the upper half of the meter scale of the

VTVM if reasonable caution is exercised in making the comparison. Thus, to improve the accuracy during an accelerometer calibration, an acceleration level is chosen which will permit a meter reading somewhere in the upper half of the scale. With these precautions, the total summed error for the voltage measurement of an accelerometer output is maintained less than ±1.0 percent.

FREQUENCY MEASUREMENT ERROR

By properly employing an electronic counter continuously during an accelerometer calibration, the excitation frequency error is reduced to a minimum which never exceeds 0.06 percent. This accuracy is accomplished by counting the signal period at low frequencies and the signal frequency at the high frequencies. The minimum error of 0.01 percent occurs at 100 cps and 2000 cps with the maximum error of 0.03 percent occurring at 316 cps. Since the relation between frequency and acceleration given in Equation 1 involve the frequency squared, the frequency error must be doubled. Thus, the total error from the frequency measurement never exceeds ±0.06 percent.

COMPUTATION OF TOTAL ERROR

The errors discussed in the last several paragraphs are summarized as follows for the low and high frequency extremes.

TABLE II

Type of Error	Maximum Error	
	100 cps	2000 cps
Micrometer microscope calibration error	±0.1 %	±0.1 %
Reading error in displacement amplitude measurements	±0.1 %	±1.0 %
Calivolter Calibration error	±0.25%	±0.25%
Voltmeter reading error	±0.50%	±0.50%
Harmonic distortion error	±0.25%	±0.25%
Maximum Freq. measurement error	±0.06%	±0.06%
Sum Total of Errors	±1.26%	±2.16%

These results assume that all the errors will be positive or all negative for a given measurement. Seldom will this occur and thus the true error is probably somewhat less. The writer believes the errors encountered in an accelerometer calibration within the frequency limits noted above are less than ±2 percent.

APPLICATIONS

The accelerometer calibration system described in this report was designed to calibrate accelerometers to be used as laboratory standards. The test accelerometers are then compared with the standard accelerometer. This calibration system can also be used in any application where small motions less than 0.001 inch amplitudes are to be dynamically measured. Thus, capacitance gauges, variable reluctance transducers, and other electronic or optical systems used to measure small motions can be calibrated with this instrument. Finally this optical system can be used to measure any very small fixed distance.

RECOMMENDATIONS

Continued investigation of methods to reduce system and random errors is planned. Some of the measurement errors can be significantly reduced. First, the error in the stage micrometer calibration due to the slide micrometer limitations can be reduced. The stage micrometer scale divisions can be accurately checked with an interferometer to approximately ±0.5 microinches instead of the ±5.0 microinch limitation now encountered. Secondly, the voltmeter reading error can be reduced by employing an extended scale with smaller and more accurate divisions. A third improvement would be a more narrow optical slit. It is believed that a 20 microinch slit can be made. Also, additional tests should be made to improve the masonite plate accelerometer mount. Additional materials should be tested in an effort to find one which would have a better transmissibility curve. Finally, a better temperature control would be desirable.

ENGINEERED TESTING

ENVIRONMENTAL TESTING

Test equipment for the following environmental conditions is available in the laboratory as follows:

VIBRATION:	600# force; 2000 cps
ACCELERATION:	50# @ 50 g's
SHOCK:	Per Spec. 7201
TEMPERATURE: & HUMIDITY:	200°F 100% R. H.
TEMPERATURE: & ALTITUDE:	−100°F to +200°F 100,000 ft.
HIGH TEMP.:	To 1,000°F
RAIN:	4" per hour
SUNSHINE:	Per MIL-E-5272A
EXPLOSION:	Per MIL-E-5272A
FUNGUS:	Per MIL-E-5272A
SALT SPRAY:	Per MIL-E-5272A
SAND & DUST	Per MIL-E-5272A

All environmental equipment is suitably instrumented with recording, indicating and controlling devices and fully complies with the requirements of the Military Specification MIL-E-5272A.

FUNCTIONAL TESTING

Supplementing the normal services of an environmental test facility, Parameters, Inc. is also capable of functionally testing all components. Parameters, Inc. maintains a complete hydraulic, electronic and mechanical test facility to provide a 'one-stop' testing organization.

HYDRAULIC PUMPING UNITS

Flows to 100 gpm
Pressure to 5,000 psi dynamic
30,000 psi static
Fluids JP-4, JP-5, Varsol MIL-0-5606, OS45 MIL- -7808

PRIME MOVERS

Power from 1/20 to 160 HP; controlled variable speeds.

HYDRAULIC IMPULSE

Per MIL-5512-A

ELECTRICAL POWER

400 amp, 3 phase, 60 cps; 28 volts d-c; 400 cps.

INSTRUMENTATION — General electronic test equipment, including recorders, oscilloscopes, meters and oscillators. Transducers including flowmeters, pressure transducers, thermocouples and potentiometers.

SPECIAL EQUIPMENT — Specialized equipment for testing electro-hydraulic closed loop systems includes variable gain servo-amplifier, sine wave generator, phasemeter, servo valve and rotary and rectilinear potentiometers.

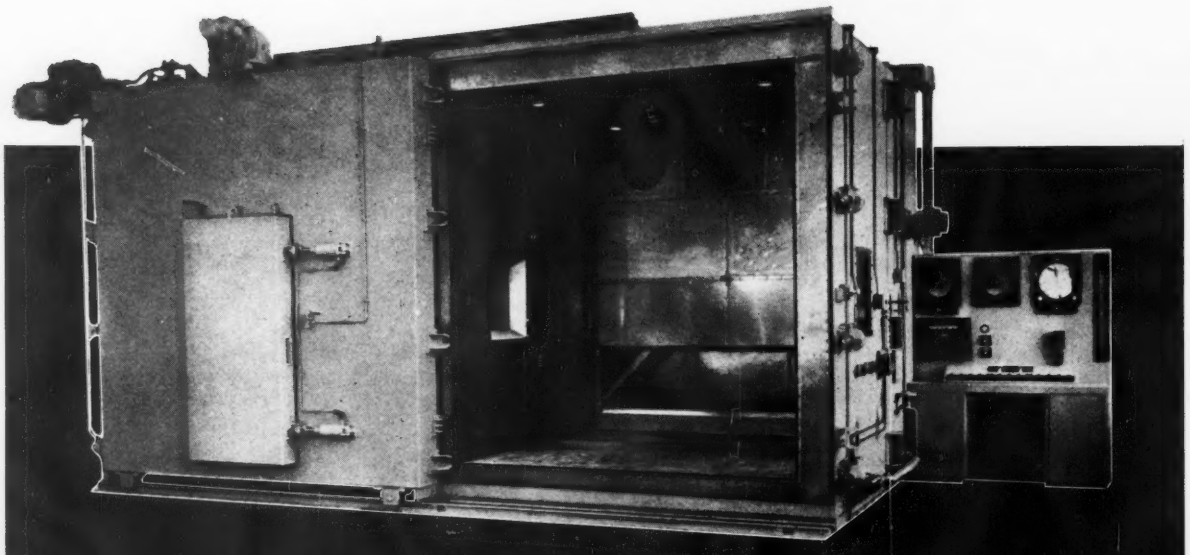
FOR MORE INFORMATION ABOUT THE TESTING, ENGINEERING, DESIGN OR DEVELOPMENT FUNCTIONS OF PARAMETERS, INC., WRITE TO:

PARAMETERS, inc.

195 HERRICKS ROAD
NEW HYDE PARK
NEW YORK
Pioneer 7-8484

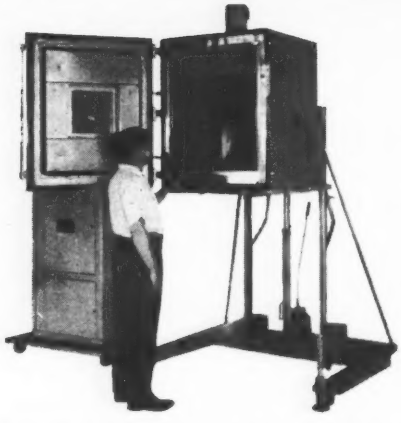
For big walk-ins, small portables, or sizes in between,

check with CONRAD Inc.



1000 CU. FT. This temperature-altitude-humidity chambers is the latest of several Conrad chambers installed at one of the nation's largest missile component plants. Temperature range, —100° F. to +350° F.; altitude, 0 to 100,000 ft.; humidity automatically programmed from 20% to 95%. Capable of dissipating 10,000 watts at —100°F.

Other features include rain simulation for testing in accordance with Mil. Spec. 5272 — push-button control for stopping door at any point within a fraction of an inch — push-button alarm system — and inter-com.



8 CU. FT. Adjustable temperature-vibration test chamber. Refrigeration effect is accomplished with liquid CO_2. High temperature limit, +1000°F. Entire unit, including control panel, full mobile.

CALL OR WRITE FOR COMPLETE INFORMATION

Main Office: Conrad Square, Holland, Mich.

ALA.: **HUNTSVILLE**
Donald R. Boyson
1404 Locust St.
JEfferson 6-9313

CALIF.: **PASADENA**
E. A. Wright
3848 E. Colorado Blvd.
RYan 1-0181

COLO.: **DENVER**
Vernon Parrish
1810 S. St. Paul
SKyline 6-6884

CONN.: **KENT**
R. M. Alden
Box 278
WAlker 7-3319

FLA.: **CLEARWATER**
W. Ben Wimberley Co.
532 S. Ft. Harrison Ave.
3-7072

FLA. **ORLANDO**
W. Ben Wimberley Co.
GArden 5-3083

GA.: **ATLANTA**
Ben T. Schladenhauffen
Lew Wright
3230 Peachtree Rd., N.E.
CEdar 3-5519

ILL.: **CHICAGO**
William Nostrand
5329 W. Belmont Ave.
AVenue 3-6111

MO.: **ST. LOUIS**
Warren Hull
828 Thornberry
TAylor 2-2241

N.Y.: **NEW YORK CITY**
Ralph M. Alden
21 Park Pl.
BArclay 7-7583

OHIO: **TOLEDO**
M. Denver Armstrong
P.O. Box 294

TEXAS: **DALLAS**
W. N. Wright
5738 N. Central Expressway
TAylor 4-2571

TEXAS: **HOUSTON**
N. Gene Simpson
1803 Calumet St.
JAckson 3-5651

UTAH: **SALT LAKE CITY**
Vernon Parrish
1810 S. St. Paul
Denver, Co'o.
SKyline 6-6884

CANADA: **TORONTO, ONT.**
Donald E. Beechey
290 Lawrence Ave., W.
RUssell 7-3861

FREE ATMOSPHERE AND TEMPERATURES CHART. Convenient pocket-size table of pressures from 0 to 1,800,000 ft. Write direct or ask your Conrad representative.

NEW PORTABLE TEST CHAMBER

Fits into 19" Relay Rack

CONRAD Inc.

TEMP-RAC 19

TEMP-RAC 19 is a 1½ cu. ft. chamber with a choice of precision-controlled temperature ranges — —100°F. to +350°F., or —70°F. to +300°F. — for testing components and sub-assemblies in accordance with military specifications. It's *convenient* — fits into standard 19" relay rack. It's *economical* — you can install several in your plant for new versatility in testing small components. And it's *quality* — engineered and built by Conrad.

★ *Fits your Standard 19" Relay Rack, Or Can Be Supplied Ready-Installed in Rack.*

★ *Temperature Ranges, —70°F. to +300°F. and —100°F. to +350°F.*

★ *Temperature Stability to Within + or —2°F.*

★ *Portable*

★ *Air Cooled*

★ *Operates From Single Phase Power*

★ *Occupies Only 4. Sq. Ft. Floor Space*

★ *Saves Time, Work, Operational Costs*

For More Information, Write Conrad or Your Nearest Conrad Representative

flight testing on the ground

Environmental and Performance Testing for Quality Control, Reliability, and Qualification of Electrical, Electronic and Electro-Mechanical Components, Sub-Assemblies and Assemblies

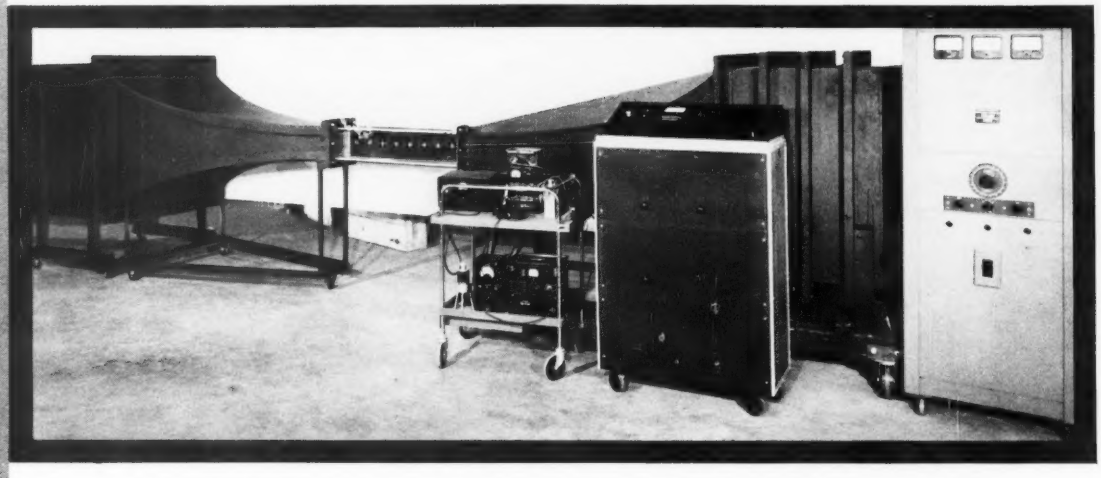
RANDOM NOISE ACOUSTICAL TESTING

Frequency spectrum: 75 cps to 10 K cps

Sound pressure level:

153 db (re: .0002 dynes/cm^2) in test chamber 5" x 5" x 16"
150 db in test chamber 8" x 8" x 40"
135 db in test chamber 40" x 40" x 40"

INTERMEDIATE SOUND PRESSURE LEVELS AND CHAMBER SIZES ALSO AVAILABLE



Acoustical vibration has recently been found--by the major airframe and missile manufacturers--to be an environment of prime importance in structures and electronic gear associated with jet and rocket engines. Rototest has developed and has operational a complete facility for testing components in high intensity sound vibration; much exceptional behavior has already been found in parts subjected to this environment.

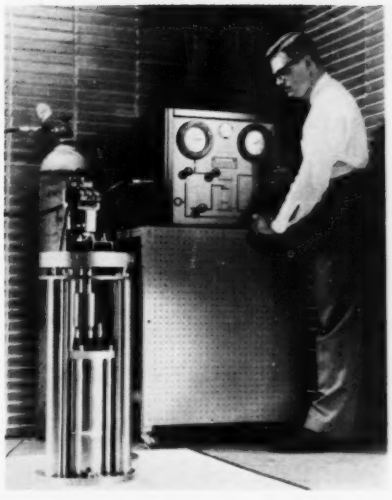
Rototest is accepting requests for proposals to supply complete Acoustic Vibration test facilities.

ANOTHER ROTOTEST FIRST

CINE-RADIOGRAPHY: *Dynamic application of X-ray motion pictures to the study of behavior of electrical, electronic, electro-mechanical, hydraulic components, assemblies and sub-assemblies while under such environmental stresses as vibration and shock.*

rototest laboratories, inc. *2803 Los Flores Blvd., Lynwood, California*

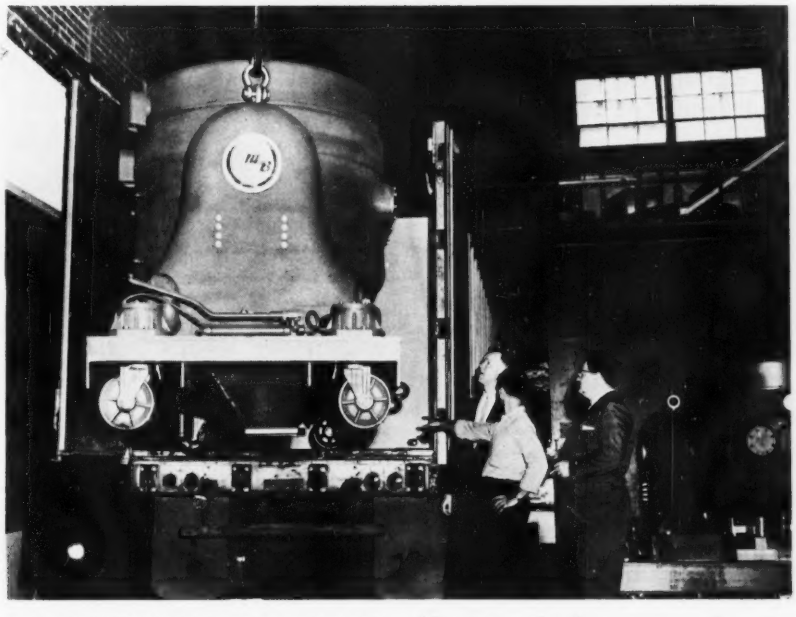
NEW products



NEW PRODUCTION-LINE SHOCK TESTER

Consolidated Electrodynamics Corporation, Rochester Division, has developed a compact shock tester which repeats either of a choice of two widely specified shock pulses in rapid succession. Designed for on-the-line testing of high-volume production items, this new Hyge-6500 can perform a complete test cycle every minute. Unlike other units which require disassembly for a change of waveform, external adjustment permits change-over of the Hyge-6500 in just a minute or two.

Unit cost is kept low by limiting capability to the two shock test specifications most frequently encountered in volume production: MIL–E–5272A (11 ± 1 ms Half-sine), and Ramo-Woolridge (6 ± .5 ms Sawtooth). Purchase price is less than that of other testers limited to a single waveform. Use of compressed bottled nitrogen as the power source keeps operating cost down to an average of 5¢ per test.



WORLD'S LARGEST VIBRATION TEST SYSTEM

NEW HAVEN, CONN.--The world's largest vibration test system left here en route to Sperry Gyroscope Company, Great Neck, N. Y. where it will be used by the company's Countermeasures Division in testing components for high-performance aircraft and missiles. According to George H. Mettler, president, MB Electronics, manufacturer of the test system, vibration is the biggest single reason for the currently low operational reliability of missiles -- accounting for some forty per cent of all known failures to date.

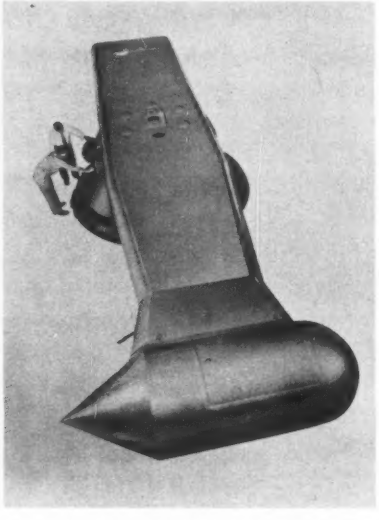
Each of the two giant vibration exciters is capable of shaking components weighing as much as 2150 pounds at up to 10g acceleration. The giant shakers weigh 35,000 pounds each. And the electronic power amplifier and associated gear weigh in at approximately 22,000 pounds.

The Hyge-6500 tests specimens ranging in weight from a fraction of an ounce up to 150 pounds.

Specifications and application data are included in Bulletin 4–75, available from Consolidated Electrodynamics Corp., Rochester Division, Rochester 3, New York.

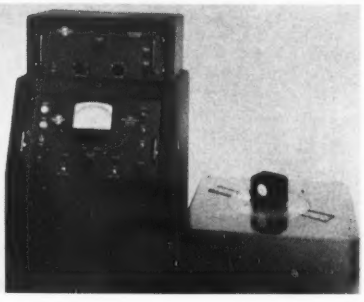
TEST INSTRUMENT CATALOG

B & K Instruments, Inc., 3044 West 106th Street, Cleveland 11, Ohio, announces the release of a new 24 page catalog listing the complete Bruel & Kjaer line of integrated instruments for automatic measurement of SOUND, VIBRATION and STRAIN.



Model RCT-21 Centrifuge Acceleration Test Machine, produced by The Rucker Company, Oakland, California manufacturer of hydraulic power systems and missile ground support equipment.

THE RUCKER COMPANY
4709 San Pablo Ave.
Oakland 8, Calif.



OSCILLATING RATE TABLE MODEL 60A

A New Type, Angular Oscillating Table for Rapid Frequency Response Testing of Rate Gyros and Angular Accelerometers will be Demonstrated for the first time at the 1959 WESCON Show, Booth 3613.

SPECIAL FEATURES:

--Frequency Coverage: 0.1 to 150 cps

--Holds constant sinusoidal rate as frequency is changed.

--With associated D.C. servo power amplifier, natural frequency exceeds 150 cps.

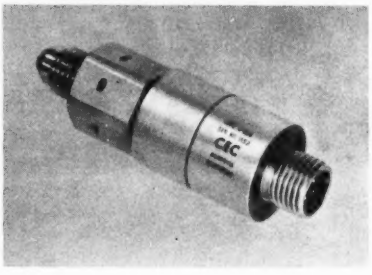
--Takes loads in excess of 100# (with decreased performance)

--Auxiliary Recorder Console available for automatically recording Frequency Response on an X–Y Recorder. Shows Natural Frequency and Damping Ratio at a glance.

--Low Distortion comparable to that found in Micro Gee Simulation Tables.

--Suitable for dynamic threshold testing of gyros and accelerometers.

Manufactured by MICRO GEE PRODUCTS, INC., Box. 1005, 6319 W. Slauson Avenue, Culver City, California.



NEW CEC PRESSURE PICKUP

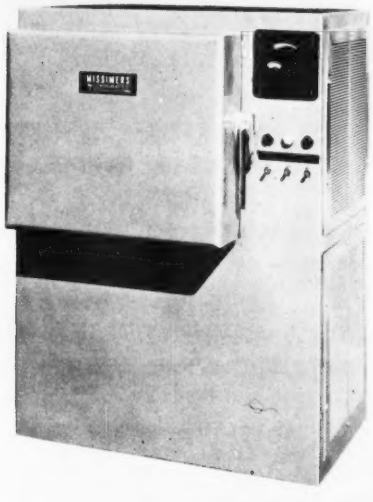
A new chamber-type unbonded strain gage pressure pickup by the Transducer Division of Consolidated Electrodynamics Corporation retains its accuracy at pressures to 10,000 psi absolute or sealed gage.

The Type 4–326 Pressure Pickup has provisions for adjustment of bridge balance, temperature compensation, and sensitivity in a chamber isolated from the sensing element. Each pickup can be adjusted to the performance specifications of the user without affecting the precision sensing element inside, making premium specifications possible at slight cost.

Transducers with nominal output sensitivity of 40 mv are obtainable to operate in pressure ranges as low as 0–100 psi and in steps up to 0–10,000 psi. Pressure limit is 1.5 times rated pressure without calibration shift

and two times rated pressure without permanent damage.

More information is in Bulletin 1620 available from Consolidated Electrodynamics Corporation, 360 Sierra Madre Villa, Pasadena, California.



LOW COST TEMPERATURE CHAMBER

A new "packaged" high and low temperature chamber which plugs into any 115 volt power source has been introduced by Missimers Incorporated, according to Dale J. Missimer, Jr., vice-president of the firm.

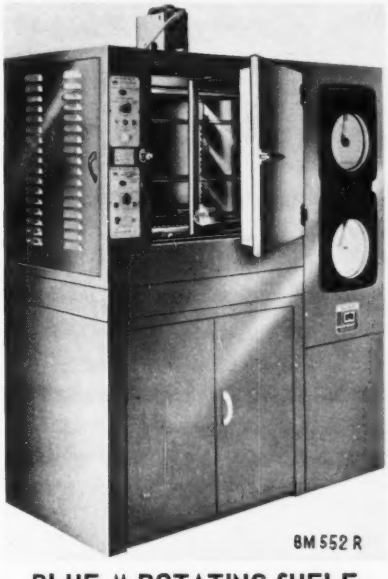
Missimer said the new chamber was designed specifically to fill the need in testing laboratories for an inexpensive, small unit that will also maintain close temperature control.

In addition to Mil-Spec qualification and reliability testing of small products or components, the chamber can be used for hot or cold treatment of metals, and for production processing and temperature stabilization of work.

Temperature range is from -100 to 350° F, using a hermetically-sealed, cascade refrigeration system, and a special heating system. Accuracies are controlled to ±3° F over the full temperature range, according to Missimer.

This unit, designated Model FT1-100X350, has a working space of one cubic foot, and outside dimensions of 35" wide x 24" deep x 45" high.

Literature on this new test chamber is available from the manufacturer, Missimers, incorporated, 3737 San Fernando Road Glendale 4, California.



BLUE M ROTATING SHELF ASPHALT OVEN

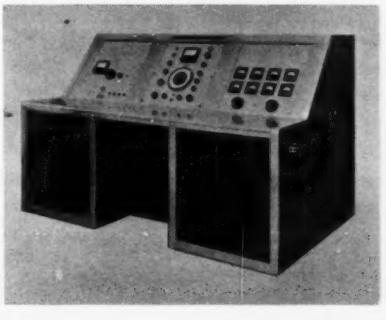
VERSATILE AND DEPENDABLE

While specifically designed to meet ASTM Specifications, simple removal of rotating shelf and extended shaft, allows this gravity convection unit to become a utility oven suitable for analytical laboratory and general chemical work.

SPECIFICATIONS AND CONSTRUCTION

Polished stainless steel interior and exterior - double wall housing and door. All 6 sides insulated with 2" Fiberglas. Dual MODELLA Heating Elements which will actually withstand 2150° F.

BLUE M ELECTRIC COMPANY
138th & Chatham Street
Blue Island, Illinois



NEW 3-KW POWER AMPLIFIER FOR VIBRATION TESTING

NEW HAVEN, Conn. -- A new 3-KW amplifier has been announced by MB Electronics (formerly MB Manufacturing Company), a Division of Textron Electronics, Inc. Designated model T-151, this console unit's distortion is less than 5 per cent at full output. Noise and hum level is at least 40 db below signal level at full output.

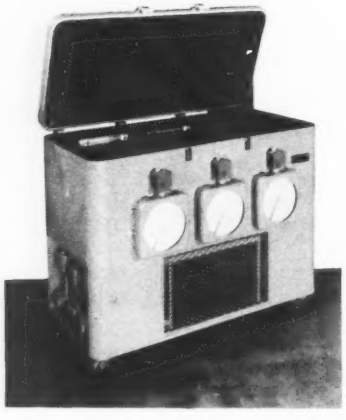
This amplifier features a new automatic power factor corrector, and a new 5-5000 cps wide band cycling oscillator with automatic acceleration and displacement control.

T–151 SYSTEM PERFORMANCE

Esciter Model	C10	C20*	C25H & C25HB
Frequency Range, cps	5-3000	5-3000	5-2000
Force-lbs. Vector	1200	1300	2200
Velocity Limit	34"/sec.	25"/sec.	30"/sec.
Displacement Limit	1" DA	1" DA	0.5" DA

*Additional field supply required

For further information, write MB Electronics, Box 1825, New Haven, Conn.



MULTIPLE TEMPERATURE CHAMBER

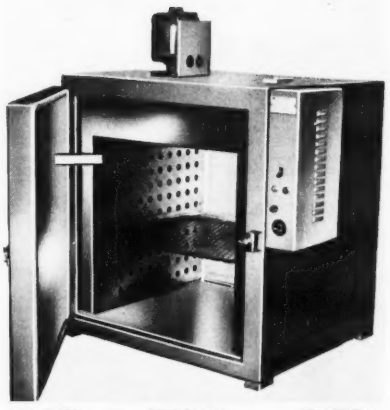
CINCINNATI SUB ZERO PRODUCTS announce the Model SV3–75–5, as illustrated, which was designed formultiple testing. Equipped with three stainless steel test cells, each having a net test area of 14" long x 14" wide x 14" deep, the following operation is provided.

Test Cell "A" provides a temperature adjustable from 0 to –20 °F.; Test Cell "B" from –35 to –45 °F.; and Test Cell "C" from –60 to –75 °F.

A cascade refrigeration system equipped with 3/4 and 1 hp accessible hermetic motor compressors, provides the refrigeration for all three cells. Each compartment is individually controlled and operation is charted by individual Recording Thermometers. For minimum temperature variation, an 8" air circulator is provided for each area. Plexiglass inner lids cover each cell to minimize temperature loss and variation when any of the adjoining cells are open.

Outside cabinet dimensions are 46" high x 58" long x 37" wide. Casters are provided for portability. Total.weight is 1400 lbs.

For additional details, contact CINCINNATI SUB ZERO PRODUCTS, 3932 Reading Road, Cincinnati 29, Ohio.



BLUE M STABIL – THERM

TEMPERATURE RANGES

100 °F. to 300 °F.
or
100 °F. to 500 °F.

8 CU. FT. HEATED VOLUME AT LOW COST for: Electronic Component Processing, Plastic Heat Treating, Paint Drying and Baking, Aging, Curing, Annealing . . . plus many other processes and tests.

. . . large volume capacity series of reliable, bench style batch ovens for production and tests in the electronic, paint, steel, rubber, aircraft, chemical and other industries. LOW COST INITIAL INVESTMENT for heat processing variety and quantity of piece parts. Eliminating use of alloy interiors, wattage proportioning, special transformers and instrument, etc., lowered the selling price. Utilizing horizontal airflow quality motor/blower combination, ETERNA Heater Banks and a relatively noncomplicated control system, a good unit is available at reasonable cost.

BLUE M ELECTRIC COMPANY
138TH & CHATHAM STREET
BLUE ISLAND, ILLINOIS

Continued on page 34

1960 NATIONAL MEETING

The Institute of Environmental Science is pleased to announce that preliminary preparations for their 1960 National Technical Meeting and Exhibition have been completed. The meeting will take place at the Biltmore Hotel, Pershing Square, Los Angeles, California, on April 6, 7 and 8, 1960.

Theme for the National Meeting is "Hyper-Environments. . .Space Frontier". The Exhibits will follow suit with a theme of "Product Design with Environment in Mind".

If you are a manufacturer or designer of aircraft, rockets, satellites, missiles or components used in such vehicles, or if you are a manufacturer or user of test facilities engaged in hyper-environmental testing of basic parts or materials or complete air or space born systems, we invite you to accept a unique opportunity to publicize your products or your skill applicable to the field of environmental testing, simulation and reliability. We also wish to point out that only exhibits compatible with the theme will be accepted. The attendees at this meeting are not interested in viewing or discussing the ordinary chamber or product currently in use, but rather, the unique, the special, the advanced designs needed for hyper-environments.

This Technical Meeting with its associated Exhibits, is the first of its kind to be held on the West Coast, yet already a tremendous interest is being shown. You are urged to contact the Exhibit Chairman, Mr. Bruno J. Forsher, 16556 Bircher Street, Granada Hills, California, as soon as possible, to secure space for your exhibit. He will gladly provide details on rental of space, booth facilities and services which will be available.

It should also be pointed out that our 1960 National eeting will attract an estimated 2,000 engineers and technical personnel engaged in work related to environment and reliability. This meeting, due to the recent merger of the Society of Environmental Engineers, who were primarily located on the West Coast, and the Institute of Environmental Engineers, who were located more in the Mid-West and East Coast areas, will of course be on a much larger scale than the preceding meetings held in Chicago and New York.

A very excellent Technical Program is being planned with many papers by prominent authorities already accepted by the Technical Program Committee. Several of the papers being considered, promise to be of world-wide importance. The show will be fully covered by press, radio and television. May we refer you to the August, 1959, issue of "The Journal of Environmental Engineering" for details on the Technical Program.

For additional information, please contact the Exhibit Chairman.

Sincerely yours,

Bruno J. Forsher

Seated, Left to Right: John R. Grimm, Charles H. Callier, Neal Granick, David M. Rees. Standing, Left to Right: William R. Lull, Earl J. Bruns, Phillip A. Simmons, George W. Heck, Robert A. Rogers. Not Shown: Allen J. Brungard, Stephen J. Brumble, Virgil C. McIntosh, Robert B. Boggild, Loren E. Bollinger.

ENVIRONMENTAL HANDBOOK

Every engineer, who has worked in that field of technical specialization known as Environmental Engineering, has sensed the remarkable degree of infancy of major portions of the field. One of the most glaring symptoms of this has been the absence of a well established handbook· defining recommended practice. There are many good reasons why the relatively unbounded nature of environmental technology is not easily reduced to a set of bound volumes. Not the least of these is the sheer magnitude of the task. It will take the support of a large organization, having a major interest in the progress of the field, to offer some chance of successful completionl Our national Department of Defense is just such an organization. The closer working harmony of the military services is now being utilized to assemble and publish a "Handbook of the Environment", as a part of a larger DOD effort in the area of standardization in environmental technology. Each engineer member of IES can help in this endeavor. The extent of your help will be described briefly below and in greater detail in subsequent issues of this Journal.

WORKING GROUP

The Department of Defense Environmental Working Group is an interservice activity of the Office of the Director of Defense Research and Engineering. Their principal assignment is that of the achievement of more uniform standards in environmental activities finacnied by DOD. The full scope of their efforts is still being defined, but one segment of their acknowledged problem is the preparation of a state of the art expression in the form of a handbook series. In recognition of the magnitude of this task, a special sub-group has been formed to work on this problem.

This sub-group is under the chairmanship of:

Mr. T. W. Johnson, Jr.
Naval Weapons Plant 760
Washington 25, D. C.

and its membership consists of:

Mr. J. R. Milliron
WCLODC, WADC
Wright Patterson AFB, Ohio

Dr. W. B. Brierly
QM R & E Command
Natick, Mass.

Mr. David Askin
Frankford Arsenal
Philadelphia, Pa.

This sub-group met recently and drafted a plan for the preparation and assembly of the handbook series.

PLAN

A copy of the handbook series general outline appears on page with the names of the sub-group member assigned to the task of expanding each volume outline. These gentlemen will be submitting final volume outlines late in November of this year. The task is a difficult one and they can use a great deal of assistance on this and on succeeding problems. They have appealed to the IES membership to submit comments and suggestions to the appropriate volume editor now and as the program develops.

One of the more important needs of the program will be a large staff of competent technical talent to prepare and review the material for the various volumes. If you feel that your background qualifies you to help in this activity, please write the editor of the volume(s) which which hold(s) your interest. Specific writing and editing assignments will be made after the November meeting of the Handbook Series Sub-Group. The institute provides liaison with the sub-group in the form of an IES representative at the sub-group meetings. A continuing record of subgroup progress will be available in this publication.

HANDBOOK OF ENVIRONMENT

Master Outline

Assigned to:

BuOrd – **I. General Guide to Handbook of Environment Series, and Glossary**

A. Foreword

B. Scope

C. Purpose

D. Table of Contents, and Description of Sections of the Series

E. Glossary

Army QMC – **II. Description of Environments**

Navy BuOrd – **III. Environmental Criteria**

USAF/WADC – **IV. Effects of Environments on Materials**

V. Effects of Environments on Materiel; Guidance for Preventive Design

Army Frankford – A. Common Denominators

USAF/WADC – B. Military Aeroballistic Materiel

Army QMC – C. Military Ground Materiel

Navy BuOrd – D. Military Marine Materiel

USAF/WADC – E. Military Space Materiel

Army Frankford – **VI. Environmental Testing***

VII. Index

NOTE ON CORRECTIONS: The DOD Working Sub-Group decided to eliminate a volume on bibliography by inserting lists of references in each volume. Pending completion of the full series of volumes, preparation of the index, Vol VII, will be postponed and an index in each individual volume will be necessary.

*In view of considerable effort already made by IES on this volume, it is anticipated that the institute can contribute much here.

SPS

S - The MANUAL of test procedures
P - The ENCYCLOPEDIA of test information
S - The DICTIONARY of test interpretation
For Engineers, Technicians, Management

A LIBRARY OF TESTING INFORMATION

The System of Procedure Specifications provides test procedures covering requirements of Military Specifications such as MIL-E-5272, MIL-E-4970, MIL-STD-202 and collected procedures covering particular environmental testing such as vibration, shock, climatic, etc. Each SPS is handsomely bound and available on a subscription basis. The subscription carries one year's free service which will include revisions to keep pace with all military specifications.

The large number of major industries that are now subscribers to SPS are rapidly making SPS the industry recognized standard of test information.

Phone or write for a demonstration at your plant. System of Procedure Specifications, 11916 W. Washington Blvd., Los Angeles 66, California. Phone UPTON 0–6821.

THE REPRESENTATIVE'S ENVIRONMENT

NEW REPS FOR CINCINNATI SUB ZERO

Mr. Robt. J. Jacobson, President of Cincinnati Sub Zero Products, Cincinnati 29, Ohio, announced the appointment of several new representatives in connection with custom-built equipment of their manufacture including production chilling as well as environmental test equipment. This is a part of an expansion program under way to provide closer contact with customers throughout the country.

The appointments include the following organizations:

Precision Sales Company, 8616 Georgia Avenue, Silver Spring, Md. Mr. Robert S. Williams, Owner. Territory Covered; Maryland, Delaware, Virginia, Washington D.C. and North Carolina.

L. H. Freeman Company, 5717 So. Broadway, Los Angeles 37, Calif. Mrs. L. H. Freeman, Owner. Territory Covered; Southern California.

T. S. McShane Company, Inc., 1113 Howard St., Omaha, Nebr. Joe Lang, Sales Manager. Territory Covered; Western Iowa & South Dakota.

Lawrence L. Hill, 1635 Garland Ave., Wichita, Kansas. Territory Covered; Kansas and Oklahoma.

THE V. A. SNYDER CO., INC. APPOINTED REPRESENTATIVE FOR MURPHY & MILLER, INC.

Murphy & Miller, Inc. of Chicago, Illinois, manufacturers of Environmental Testing Equipment for the aircraft, missile and electronics industry, has recently announced that the V. A. Snyder Co., Inc. has been appointed their Engineering Representative covering the states of New Jersey, Delaware, Long Island New York, New York City, and the eastern half of Pennsylvania. The V. A. Snyder Co., Inc. has been in the Environmental testing field, relating to instrument and vibration, for many years.

TEK-SEL TO REPRESENT LING ELECTRONICS

CULVER CITY, Calif. -- Tek-Sel, Inc., has been named as sales representative for Ling Electronics, Inc., in metropolitan New York, including Long Island and the counties of Westchester and Rockland, the states of New Jersey and Delaware and the eastern half of Pennsylvania.

Tek-Sel, headquartered at 54 Route 17, Paramus (New Jersey) will represent the full line of Ling electronically-driven vibration testing systems and high-power electronic equipment.

HUGHES CO. TO REPRESENT L. A. B. CORP.

The L. A. B. Corporation of Skaneateles, N. Y., manufacturers of environmental shock and vibration machines and transportation testing equipment, announces the appointment of the Don E. Hughes Co., Glendale, California as its representative in California and Arizona. The principal of this new representative organization, Mr. Don E. Hughes, has over seven years experience in the sale of environmental testing machines and associated equipment. His organization will enable the L. A. B. Corporation to provide immediate assistance and information concerning their products to their many customers in California and Arizona.

The Don E. Hughes Co.'s address is P.O. Box 1069, Glendale 5, California. Tel: CHapman 5-4720.

CHARLES W. DANIELSON
TECHNICAL EDITOR

NOTES FROM THE EDITOR

I am taking the opportunity in this issue to introduce myself to the members of the Institute of Environmental Sciences. When our national society was formed in April 1959, the Journal of Environmental Engineering, of which I was technical editor, was selected to be the official publication of the new Institute of Environmental Sciences. The transition from compiling the Journal for the old SEE, which is now the L.A. Chapter, into the Journal of of Environmental Sciences for our national organization, with an increase in circulation to over 3000, has been extremely interesting and at times hectic. A considerable amount of support from the National Board, Raymond Yaeger, VP of Publications and myself is being put into effect to make the Journal of Environmental Sciences the outstanding publication in its field. We are going to maintain the highest level of quality in our technical articles, advertisers, society news and presentation. The Journal will serve all members of the society throughout the entire U.S. in advancing the field of environmental engineering. Your National Board, VP of Publications and editor are doing their part. Now it is up to you to do your part.

The Journal is your means of informing the entire field of environmental engineering of your thoughts and developments. The October issue of the Journal deals entirely with vibration. This is one of the most important environments with which we are all concerned. However, vibration is not the only environment in which we wish to increase our knowledge. New concepts, techniques and parameters are being brought forward in the areas of radiation, solar energy, high vacuum, zero gravity, temperature, combined environments, etc. To those of you who have published articles before, we express our thanks. As a rule, in your individual fields, you will continue to publish the results of your findings. But for the people who have not had an opportunity to submit an article for publication, the Journal is ready to assist you. Rather than prepare a finished article, the Journal can assist you by editing rough drafts. We will assist you in enlarging on your draft in preparation of completing a final article for publication. This is the only way the Journal can serve its members in presenting the various activities in the environments to the entire organization. Why don't you drop us a line regarding the particular field in which you are interested. Those located east of the Mississippi can contact Raymond Yaeger, P.O. Box 191, Mt. Prospect, Chicago, Illinois. Those west of the Mississippi can contact Charles Danielson, 11916 West Washington Blvd., L.A. 66, Calif.

UNEQUALLED OPPORTUNITIES AT ENDEVCO CORPORATION

Endevco is the leading manufacturer in the nation of vibration and shock measuring systems. These are precision proprietary products; we have no government development contracts. As a rapidly growing business, we need more help at all levels—from supervisory personnel to trainees.

As electronic firms go, we are small (under 200 employees) but our people find this an advantage. It gives everyone a chance to do the kind of work he likes best with plenty of freedom and an excellent opportunity for advancement. Benefits include profit-sharing, insurance, regular salary reviews and many others. All positions permanent, citizenship not required.

Application Engineers to develop customer applications. Knowledge of transducers desirable. BS, ME, EE or Physics Degree required.

Product Development Engineers to design and analyze products in the electromechanical instrument and electronic fields. Men needed at Senior and Junior levels.

Mechanical Standards Engineer to establish new product test procedures, mechanical standards and design of test fixtures. Desire BS, ME with vibration test experience.

Quality Control Supervisor to supervise inspection, instrument calibration and electronic test department. Administrative experience in quality control desired.

Design Draftsmen to design tooling and fixtures. 5 years experience.

Send for free booklet: "This Is Endevco"

Interviews arranged at your convenience and in complete confidence. Apply Personnel Department 9 to 5. MUrray 1-5231, Extension 100.

ENDEVCO CORPORATION
161 EAST CALIFORNIA BOULEVARD
PASADENA

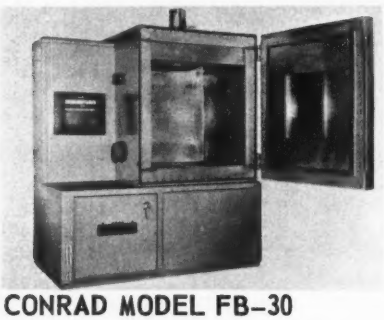
dynamic instrumentation

FREEDOM

Our inertial guidance systems utilize two-degrees-of-freedom gyros. If you would like to do advanced work with these and have had at least a year of engineering experience, please write Mr. C. T. Petrie, Manager, Research & Engineering Staff.

LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California

Continued from page 28



CONRAD MODEL FB–30

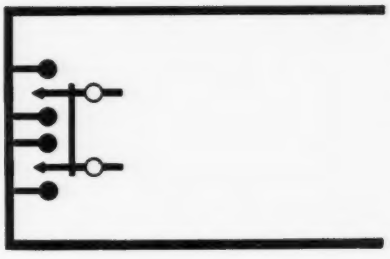
This photograph shows a Conrad Model FB–30, high low temperature test chamber, with a range of +300° F. to −100° F. Standard equipment on the chamber include a 24" x 24" multipane viewing window, externally mounted ball bearing circulator motor, and an electrical panel equipped with a manual disconnect switch for servicing. The unit is water cooled, and comes either equipped with two 3 h.p., two 5 h.p., or two 7½ h.p. refrigeration units, depending upon the users requirements. The chamber is equipped with a cabinet drain, and requires only one power connection, and two water connections to put the unit into operation. A smooth linoleum type work deck is installed for the convenience of the operator (instrumentation and port holes shown in this photograph are optional equipment).

CONRAD, INC.
Conrad Square
Holland, Michigan

FIELD OFFICES:
Boston, New York, Kent, Winston-Salem, Clearwater, Toledo, Atlanta, Huntsville, Chicago, Houston, Dallas, Denver, Salt Lake City, Pasadena, Toronto.

Subsidiary of Crampton Manufacturing Company.

TECHNICAL INFORMATION



COMPLEX VIBRATION TRAINING SEMINAR ANNOUNCED

MB Manufacturing Company will hold a series of training seminars on complex vibration testing starting in June, 1959, it was announced by George Mettler, president.

Each seminar will last two weeks. It will consist of lectures at Yale University under the direction of Dr. Theron Usher of the University's Electrical Engineering department and demonstrations and practice with equipment of MB facilities. Seminars will be held monthly and limited to ten men.

The course will include:

1. Basic random noise theory
2. Principles of operations of exciters
3. Equalization procedures and techniques
4. Power amplifier requirements and basic design
5. Limiters and protective devices
6. Measurement, display and recording techniques
7. Basic sinusoidal testing techniques
8. Practice in operations of typical systems

For further information write to Wayne Tustin, Preliminary Design Engineer, MB Manufacturing Company, 781 Whalley Avenue, New Haven, Conn. ■■■

ALUMINUM CONSTRUCTION MANUAL

Reference book for use by engineers, designers, and students concerned with the use of aluminum in stressed structures; includes allowable load data for aluminum alloy 6061-t6

Write to: The Aluminum Association
420 Lexington Avenue
New York 17, N.Y.
Price $3.00

UNIFORM DUPLICATION OF ENVIRONMENTAL TEST RESULTS

WADC Technical Report 58-613
ASTIA Document No. AD205774-5-6

Results of a survey conducted by Inland Testing Laboratories for WADC among 286 companies. The results of the survey are presented in three parts; Part I Information Survey, Part II Survey Analysis, Part III Evaluation Test Program.

Duplication of Low Temperature, High Temperature, Humidity, Sand and Dust and Temperature Shock tests as specified in MIL-E-5272 and MIL-E-4970 are discussed with recommendations.

Request on company letterhead from:

Headquarters
Armed Services Technical
Information Agency
Arlington Hall Station
Arlington 12, Virginia

BRUEL & KJAER TECHNICAL REVIEW

A periodical covering advanced techniques in the measurement of Sound, Vibration and Strain. Extremely thorough presentation of instrumentation techniques and engineering analysis.

Request on company letterhead from:

B & K Instruments, Inc.
3044 West 106th Street
Cleveland 11, Ohio

names and faces

NEWPORT BEACH, Calif., September 21 -- William L. Vandal has joined Aeronutronic, a Division of Ford Motor Company, as manager, Central Environmental Test, according to announcement by Arthur C. Haines, manager of Central Services.

Vandal will be responsible for managing the new Central Environmental Laboratory presently being built and equipped at Aeronutronic's new $22-million engineering and research center at Newport Beach, California.

Vandal was a charter member of both the Institute of Environmental Engineering and the Society of Environmental Engineers. These two organizations merged recently and formed the Institute of Environmental Services, of which Vandal is executive vice president. He has also been appointed general chairman for the National Symposia Meeting of the Institute of Environmental Sciences, which will be held at the Biltmore Hotel in Los Angeles in April, 1960. He is a member of the Institute of Radio Engineers and has presented a number of papers before various groups on environmental testing.

MB GRADUATES LING AS FIFTIETH STUDENT

NEW HAVEN, Conn. -- The fiftieth engineer to graduate from MB Electronics special series of 10-day seminars on complex motion vibration testing was Jack A. Ling, reliability engineer, Sergeant Evaluation and Analysis, Sperry Utah Engineering Laboratory, Salt Lake City, Utah. He is shown here (left) receiving his diploma from George H. Mettler, MB president.

These seminars, started in June, will continue through September. MB expects that nearly 100 engineers from the aircraft, missile, electronics, and components industries will have attended. Instructor for the course is Dr. Theron Usher of Yale University's electrical engineering department.

Norman B. Dorries, Branch Manager of The Rucker Company's enlarged facilities at 1744 S. E. Hawthorne Boulevard, Portland, Oregon. Telephone number at the new address has been changed to BElmont 4-0341.

MB ELECTRONICS APPOINTS NEW ISOMODE SALES ENGINEER

NEW HAVEN, Conn. -- The appointment of Paul A. Nissen as sales engineer for the Isomode Division, MB Electronics, has been announced by Fred Bradstreet, division manager. Mr. Nissen's responsibilities will include sales and application Engineering for MB's broad line of vibration and shock isolation mounts.

He joined MB in 1956, and worked on the design of the company's engine mounts and Isomode pad applications.

Mr. Nissen and his family reside in North Branford, Connecticut.

Electrical Testing Laboratories, Inc.
FACTS
Reliably and Impartially Reported

SPECIALISTS IN *Laboratory* MEASUREMENTS

- MICROWAVE
- RADIO
- AUDIO
- ELECTRICAL
- MECHANICAL
- PHYSICAL
- CHEMICAL

At SPECIFIED ENVIRONMENTAL CONDITIONS

Write for ETL's 64 page illustrated bulletin "A Listing of Services and Facilities."

There is no substitute for experience in the measurements field. ETL, an independent organization trained in the disciplines of laboratory measurements and determinations, has been serving industry in this field for over 60 years.

Know by ETL *Test*

ELECTRICAL TESTING LABORATORIES, INC.

2 East End Avenue at 79th Street • New York 21, N. Y. • BUtterfield 8-2600

CHEMICAL • ELECTRICAL • ELECTRONIC
PHYSICAL • MECHANICAL • ENVIRONMENTAL

TESTING • INSPECTION
CERTIFICATION

INCLUDING INFRARED SPECTROSCOPY, PHOTOMETRY, RADIOMETRY, SPECTROPHOTOMETRY AND PHOTOMICROGRAPHY

Member

NOW *Pre-engineered* ENVIRONMENTAL CHAMBERS

Model FTA

Chamber size 36″ cube
Temperatures from −100 to 350 F
Altitudes—site level to 200,000 feet

for a customized chamber with standard model economies!

The wide number of different and exacting requirements for each environmental test chamber formerly meant a custom designed unit was the only answer.

Now, however, Missimers can meet most chamber requirements by combining one of many pre-engineered conditioning systems with the desired size chamber, and adding instrumentation to suit your needs.

Missimers pre-engineered packages provide complete flexibility of size, temperature and altitude ranges, with instrumentation available for completely programmed, recorded and controlled operation.

You have the advantages of a proved system, with shorter delivery—and with the economies of a standard unit.

Missimers complete line of environmental test chambers includes extreme temperature, humidity, altitude, explosion and special chambers to meet *any requirement*. Call or write for more information on your specific needs!

MISSIMERS INCORPORATED
since 1932

3737 San Fernando Road, Glendale 4, California • CHapman 5-8471
Western Sales Representative: Pacific Scientific Company

INTRODUCING THE

NEW

TEMPERATURE ALTITUDE HUMIDITY CHAMBER

- **Temperature Range** —120°F to +500°F
- **Altitude Range** Sea level to 200,000 feet
- **Humidity Range** 20% to 95% between +35°F and +200°F, limited by a low dewpoint of +35°F.

STANDARD WORK SPACE SIZES AVAILABLE

- 15" W x 21" H x 12" D
- 24" W x 30" H x 20" D
- 35" W x 36" H x 38" D

OPTIONAL ACCESSORIES AND INSTRUMENTATION AVAILABLE

- Viewing Window
- Interior Light
- Manual Wiper
- Electric Feed-Thru Terminals
- Access Port
- Casters
- Indicating Controllers
- Recording Controllers
- Program Controllers

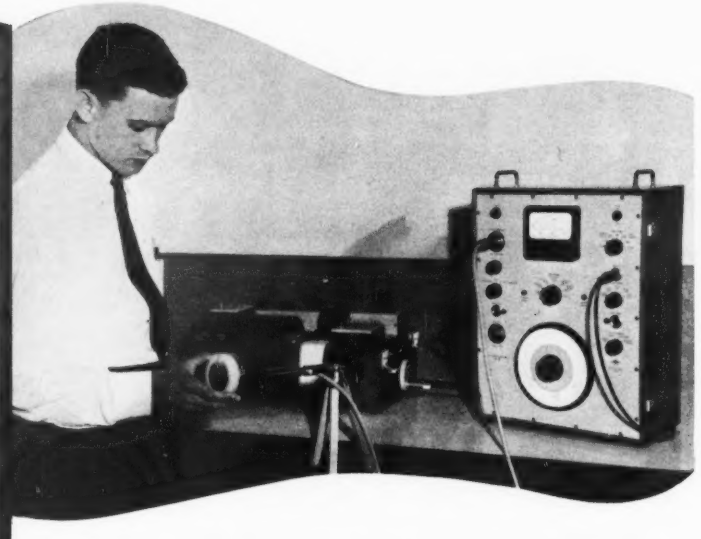
Also available

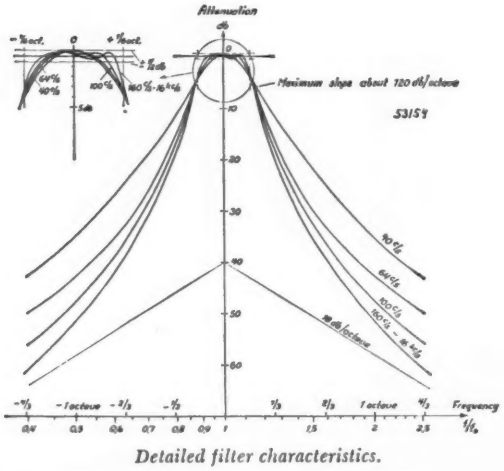
LOW TEMPERATURE
HIGH TEMPERATURE
ALTITUDE
HUMIDITY
SALT SPRAY
SAND and DUST
VACUUM OVENS
WALK-IN ROOMS
FUNGUS

ITEMCO INC.

18 BEECHWOOD AVENUE PORT WASHINGTON L I N Y

New . . . Bruel & Kjaer 1/3 Octave SPECTRUM ANALYZER





Detailed filter characteristics.

- *Analyzes Noise and Vibration in True RMS Values!*
- *Analyzes Complex Signals—14 c/s to 36,000 c/s.*
- *Analyzes Signals from 5 Micro Volts to 1000 Volts.*
- *Combines with the B & K Level Recorder for Automatic Analysis and Data Plotting.*

The new Audio Frequency Spectrometer Model 2110 features switch selection for either a true RMS, average or peak reading of analyzed data. The RMS indication is most frequently preferred for noise and vibration measurements because of its direct relation to the energy of the signal being measured.

The new model 2110 has thirty 1/3 octave band filters to extend the frequency range for complex signal analysis to be from 35 c/s to 36,000 c/s. Optional 1/3 octave filters may be added to extend the low frequency range down to 14 c/s. The spectrometer can be mechanically switched by the level recorder Model 2304 for automatic measurement and recording of spectrograms on frequency-amplitude calibrated chart paper.

Gentlemen:

Please send me

☐ Information on B & K Model 2110.

☐ B & K Complete Line Catalog.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Exclusive Franchised U. S. Marketing Agent for Bruel & Kjaer Instruments

B & K INSTRUMENTS, Inc.

3026 W. 106th STREET • CLEVELAND 11, OHIO • CLearwater 1-8430

We're Changing Our Environment

To Meet the International Demand for International Radiant Environmental Test Chambers

The acceptance for International Radiant Environmental Test Chambers by private industry and government agencies has been tremendous . . . especially for the new ThermaLine Series 400 Test Chambers. Our expanded quarters will allow us to continue to keep ahead of the rapid industry advances in order to meet these new demands. The unexcelled quality of IRC Test Chambers will remain the same, but we can now provide you with even quicker deliveries and even greater service than ever before.

IMPORTANT NEWS FOR YOU!

Coming Soon

ValuLine

Environmental Test Chambers

A Series of LOW COST Standard Production Models Featuring:

- *Designs to Meet Military Testing Requirements!*
- *Off-the-Shelf Deliveries!*
- *Budget-Stretching Facilities!*
- *Wide Range of Environments!*

WATCH for the ValuLine from International Radiant Corp. . . . SOON

NEW ADDRESS

577 E. 156th St., New York 55, N.Y. • CYpress 2-6000

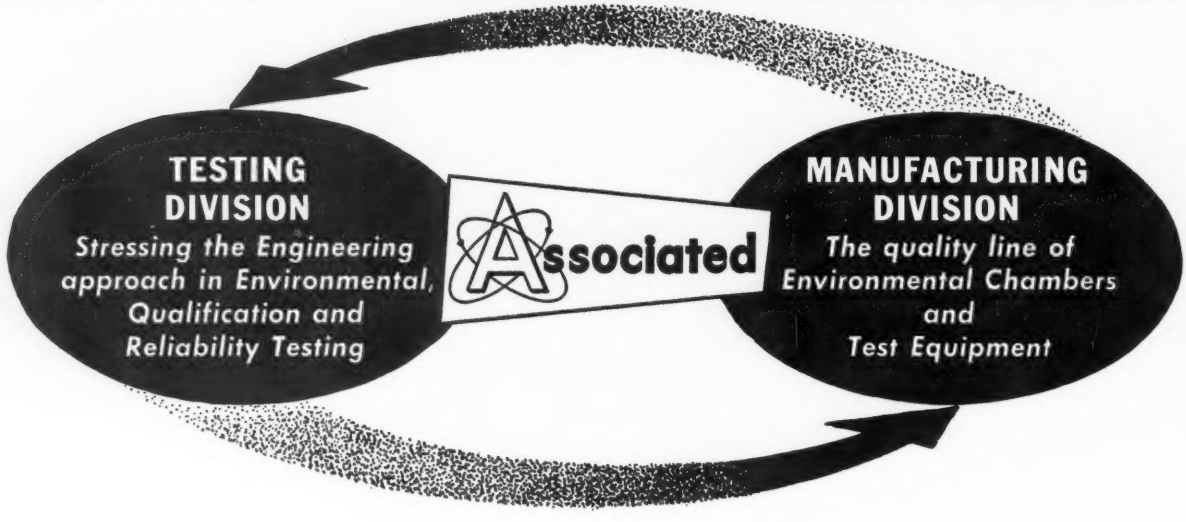
IRC

International Radiant Corporation

Subsidiary of Rubel Corporation

Tomorrow's Environments . . . Today!

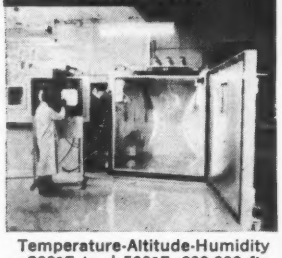
Environmental Feedback..


TESTING DIVISION
Stressing the Engineering approach in Environmental, Qualification and Reliability Testing
Associated
MANUFACTURING DIVISION
The quality line of Environmental Chambers and Test Equipment

The skill and know-how gained from the coordination of Associated's two divisions through "feedback" of information assures the proper utilization of test equipment within the Testing Division and the proper design of environmental test equipment within the Manufacturing Division.

Write for illustrated literature!

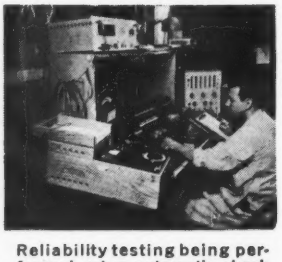
TESTING DIVISION



Temperature-Altitude-Humidity −300°F to +500°F, 200,000 ft., 5% to 100% RH, in one of more than 30 chambers available for your testing.

Sawtooth shock test being performed on a Shock Test Machine developed by Associated.

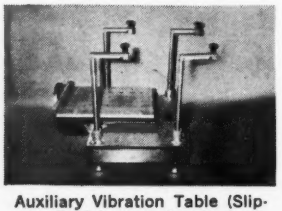
Explosion-proof testing in accordance with specifications MIL-E-005272B, MIL-E-5272C, MIL-E-5422D, etc.



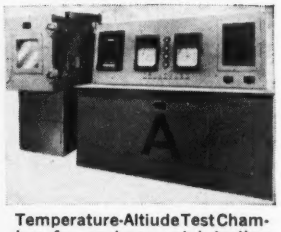
Reliability testing being performed using automatic check out panels.

MANUFACTURING DIVISION

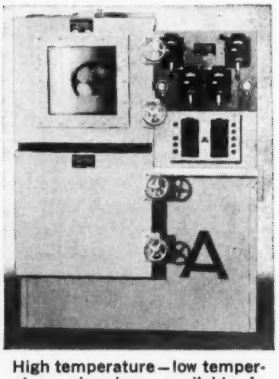
All Lucite Salt Spray Chamber built to perform tests in accordance with specifications MIL-E-5272A, QQ-M-151A, MIL-STD-202A, etc.



Auxiliary Vibration Table (Slippery Table) a complete line, adjustable in height, for use with any vibration machine.



Temperature-Altiude Test Chamber for environmental testing within the range of −300°F to +1200°F and from sea level up to 350,000 feet.

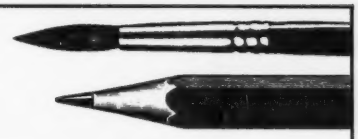


High temperature—low temperature chambers available in single or dual units for testing range of −300°F to +1200°F.

ASSOCIATED TESTING LABORATORIES, INC.

Testing Division • Manufacturing Division

136 CLINTON ROAD Telephone CApital 6-7407 **CALDWELL, NEW JERSEY**



The right TOOLS are important

... but the craftsman's skill is needed to produce quality . . .

At GUTHRIE - KIEFER CO., experience and 'know-how' are mature, with a fresh-born eagerness for the new and a zest for quality untarnished by old printing complacency.

GUTHRIE-KIEFER CO.

COMMERCIAL ART AND LITHOGRAPHY

11918 W. WASHINGTON BLVD. LOS ANGELES 66

EXMONT 1-3291

You can DEPEND on -- ***Standard***

TEST CABINETS

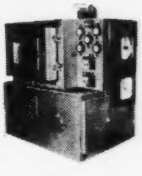
FOR ACCURATE DEPENDABLE ENVIRONMENTAL TESTS

self-contained units to meet every condition

HIGH and LOW TEMPERATURES, ALTITUDE, HUMIDITY, FUNGUS, SAND and DUST, SALT SPRAY, RAIN and SUNSHINE, EXPLOSION and SPECIAL APPLICATIONS.

WALK-IN EQUIPMENT FABRICATED TO ORDER

Every Standard test cabinet is designed for reliable and accurate testing, along with years of care-free durable operation. Whatever the simulated condition is desired to test your product accurately . . . correctly, there is a Standard cabinet to do the job. All guaranteed to give high level performance — the result of a decade of engineering skill and experience in designing and fabricating test equipment. Why not look into the many outstanding features offered by Standard today . . . send for our illustrated Catalog No. 59.



MEMBER OF ENVIRONMENTAL EQUIPMENT INSTITUTE

Standard CABINET COMPANY

50 WASHINGTON AVE.
CARLSTADT, N. J.
DESIGNERS-MANUFACTURERS OF TEST EQUIPMENT

400,000 G POUNDS

ACCELERATION TESTING with RUCKER CENTRIFUGES

Large Rucker Centrifuge Acceleration Test Machines provide accurate environmental testing of components, instruments and complete assemblies for military facilities, missile manufacturers, allied industries participating in the rocket and missile development program.

RUCKER FEATURES

- Proven design offers greatest range of simulated acceleration and combined environmental tests
- Safety factor of 5
- Counter-rotating specimen platform
- Test chambers for temperature, humidity, altitude and vibration
- Electrical slip rings
- Complete interlocking system for fail-safe operation
- Maximum accuracy through high inertia design and precision control system
- Hydraulic-pneumatic rotary joints
- Closed circuit TV
- Wave guides for all applications

Ideally suited for exacting laboratory testing or production test procedures, Large Rucker Centrifuges are available in six standard models accommodating specimen weights from 300 to 9,000 pounds and with centrifugal capacities to 150 G. Larger models custom-designed to meet special needs.

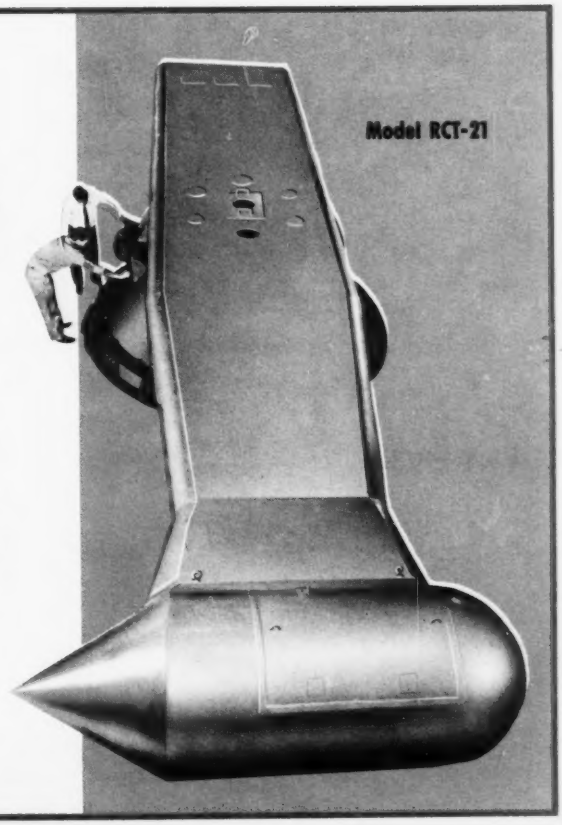
Small Rucker Centrifuges also available.

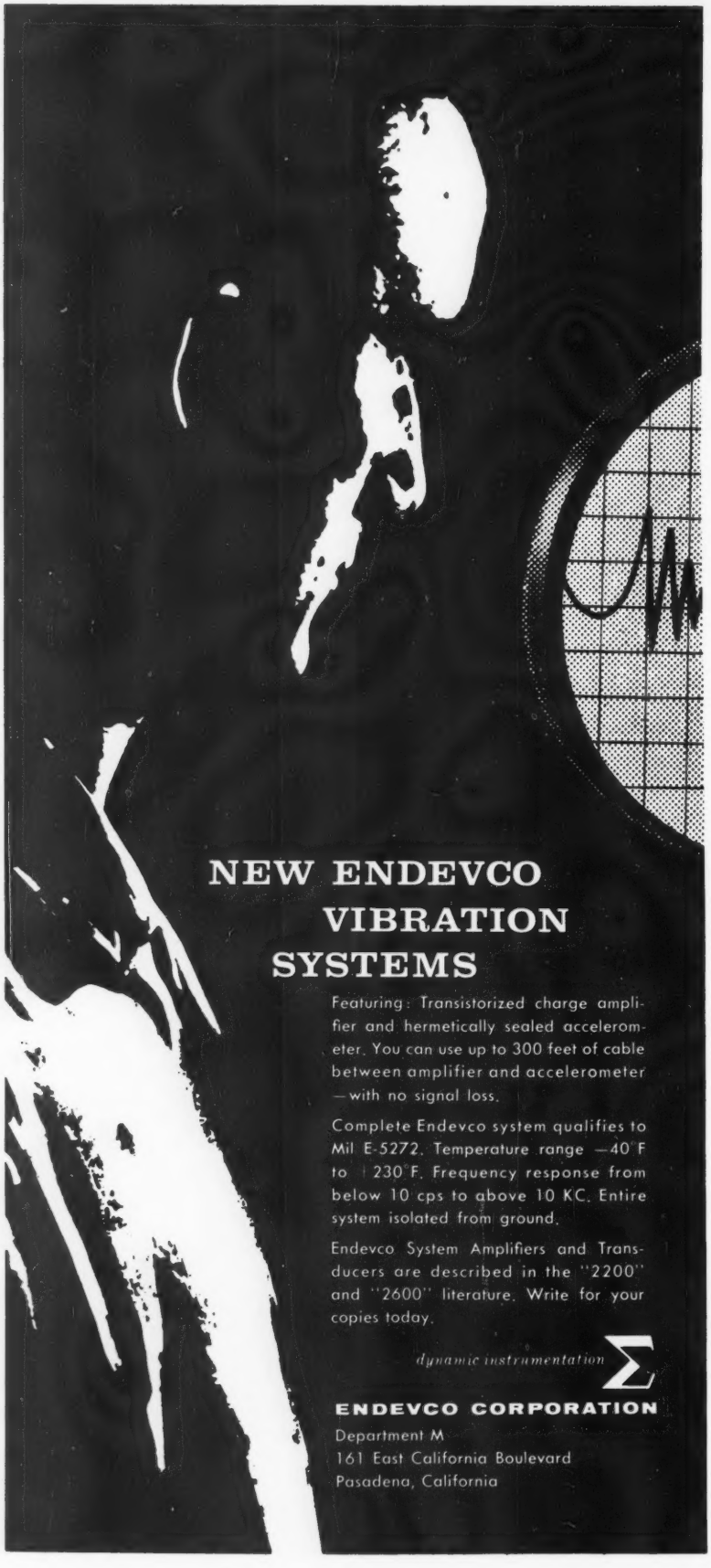
For full details, write today to

THE RUCKER COMPANY Since 1941

4700 San Pablo Avenue • Oakland 8 • California

ATTENTION: Openings now for Qualified Engineers— for Design and Sales




NEW ENDEVCO
VIBRATION
SYSTEMS
Featuring: Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer —with no signal loss.
Complete Endevco system qualifies to Mil E-5272. Temperature range —40°F to +230°F. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.
Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.
dynamic instrumentation
ENDEVCO CORPORATION
Department M
161 East California Boulevard
Pasadena, California

Membership in IES

Several classes of membership will be provided in the Institute of Environmental Sciences which parallel those of other societies, namely: Fellow, Honorary Fellow, Member, Associate Member, Student, Government Member, and Company Member. Requirements for the individual classes of membership are presently being established and will be available upon application for membership. All present members of SEE and IEE will automatically be eligible for the member classification without further qualification. Fellows and Members are eligible to vote and hold office. Associate Members may vote but cannot hold office. Student, Government and Honorary Members do not vote or hold office.

APPLICATIONS

For further information regarding membership write to The Institute of Environmental Sciences, Box 191, Mt. Prospect, Illinois. Attention: Russell Lowe, Vice President, Membership.

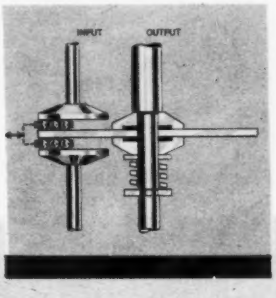
NEW GENISCO CENTRIFUGES

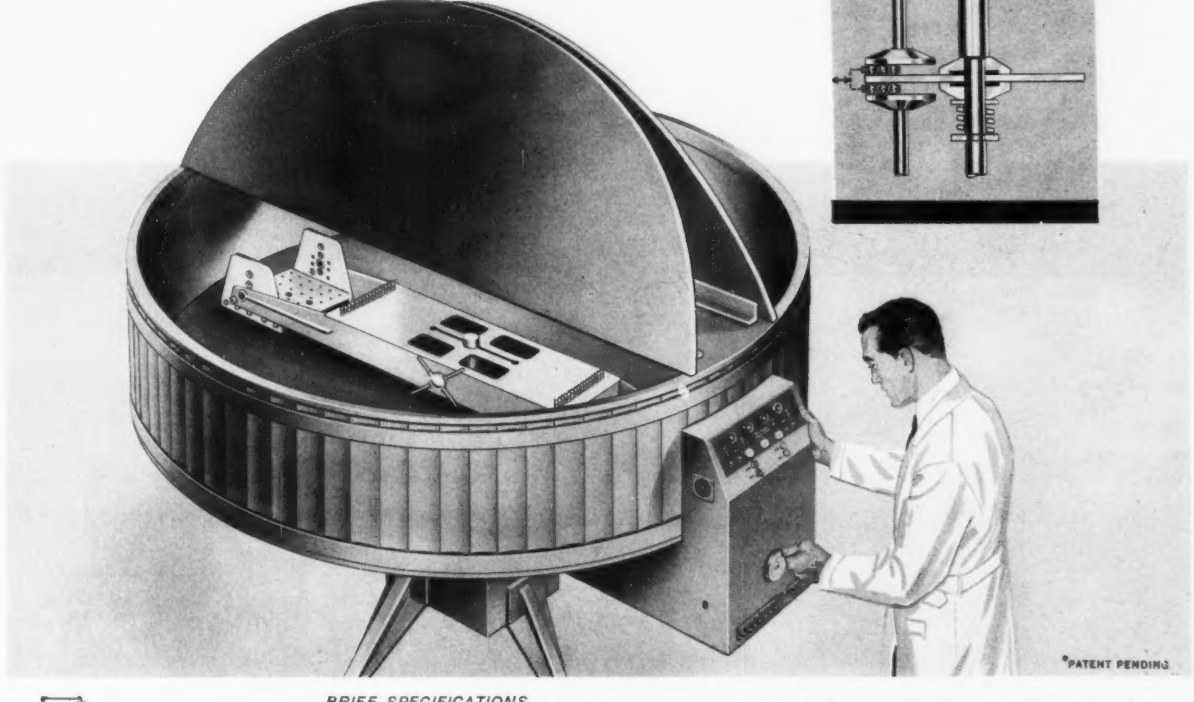
have 10 times greater accuracy, larger centrifugal capacity, greater flexibility, yet are priced lower than any other centrifuges now available.

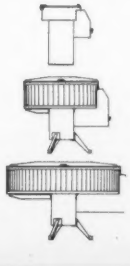
These new precision centrifuges feature a unique, high-torque, ball-disc integrator drive system. Constancy of boom rotation, including wow and long-term drift, is better than 0.05% at any speed setting—approximately 10 times more accurate than currently available machines. Boom speed is infinitely variable and is measured by an electronic counter built into the console.

Exceptional flexibility is achieved in the new centrifuges through the use of a "building block" design concept. Machines are assembled from six basic off-the-shelf components: drive system, drive motor, boom, test compartment, console and accessories. You simply select components to meet your specific requirements. Component interchangeability permits easy modification as requirements change. Kits are available for modification by the customer.

Entirely New Drive System
An integral, variable-speed transmission based on the new Rouveral* ball-galaxy principle achieves high torque characteristics while maintaining the inherent accuracies of a hardened steel-to-steel ball-disc integrator.







BRIEF SPECIFICATIONS

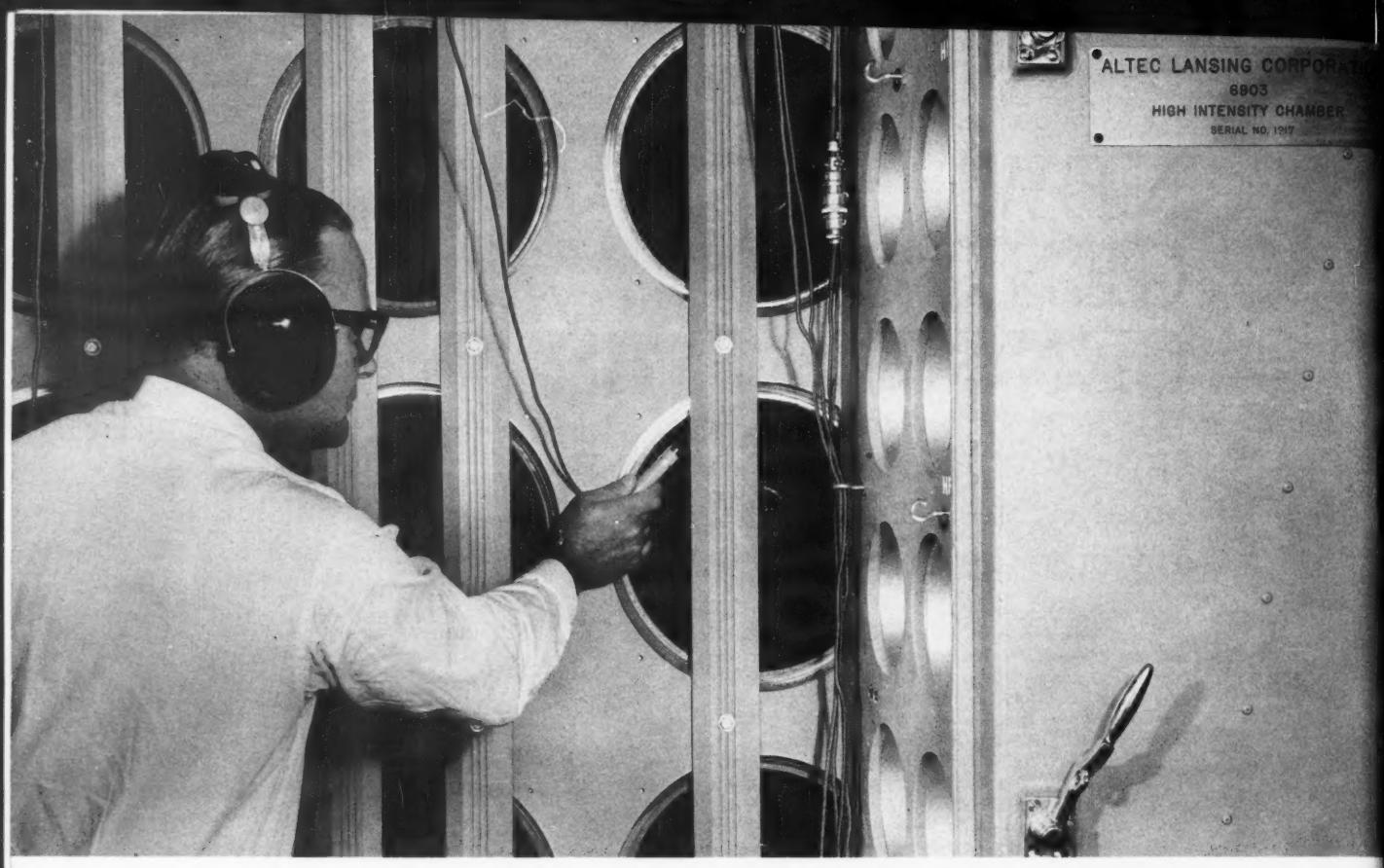
Model No.	Diameter	Test Object Weight	Capacity G-pounds	RPM Max.	G-Range Max.	Test Object Dimensions
A-1010	30" table	50 lbs. dead weight	2,500	800	.1 to 200 g's	
A-1020	60" arm	100 lbs. dead weight	10,000	600	.1 to 250 g's	12" cube
A-1030	96" arm	100 lbs. dead weight	10,000	355	.1 to 150 g's	18" cube

Ratings up to 250 g's can be furnished.

Ask your Genisco representative for complete information today.

Genisco INCORPORATED

2233 FEDERAL AVENUE • LOS ANGELES 64 • CALIFORNIA



High Intensity Sound

a destructive, powerful force... a useful, versatile tool!

The destructive forces of high intensity sound – both in vibration and heat produced – are now better understood and better controlled through the use of testing chambers such as this latest Ling-Altec Reverberation Chamber.

Here, an Engineer adjusts one of the monitoring microphones in a chamber that can produce over 150 db of white noise – enough to equal the noise spectrum of the most powerful modern jet engines.

Even greater forces can be produced in Ling-Altec Plane Wave Tubes with air modulated devices which concentrate the power of high intensity sound many times.

These developments are a part of the continuing leadership of the Ling-Altec combination – high power electronics and high intensity sound!

LING

ELECTRONICS, INC.

Factory Sales Offices: 9937 West Jefferson Boulevard, Culver City, California
1515 South Manchester Avenue, Anaheim, California
120 Cross Street, Winchester, Massachusetts